A guide to the species of the genus *Aspidisca*

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Introduction

As a sequel to 'A guide to the species of the genus *Euplotes*' (Curds, 1975) the present paper is primarily a collection of diagrams and descriptions of the species of the genus *Aspidisca* Ehrenberg, 1830 (1832). Keys to what we consider to be distinct species are included, and are designed to enable workers to make specific identifications of *Aspidisca* without the need to search the literature. Previous attempts known to the present authors are those of Plough (1916) who devised a key to eight species (see Appendix 1) and Kahl (1932) whose key included 28 species (see Appendix 2). Borror (1972), in a revision of the order Hypotrichida Stein, 1859, listed 22 species of *Aspidisca* with their synonyms. While we sometimes do not agree with Borror (1972), it should be pointed out that some of the disagreements are only matters of opinion. Information is still required to substantiate these opinions even though some effort has recently (Tuffrau, 1964; Borror, 1972; Curds, 1975, 1977) been devoted to the taxonomy of the family Euplotidae Ehrenberg, 1838. Since Ehrenberg, 1830 (1832) established the genus *Aspidisca* with *Aspidisca lynceus* (Müller, 1773) Ehrenberg, 1830 as the type species, over 50 nominal species have been transferred and added to the genus. Species have been distinguished by the size and shape of the body, the number of dorsal ribs, the presence of a thorn on the dorsal surface, the number of cirri on the ventral surface, nuclear features and the configuration of the peristome. Kahl (1932) applied all these criteria in devising his key (Appendix 2) and divided them into marine and freshwater species. Plough (1916), on the other hand, considered the shape of the 'cuirass' to be the most stable character and believed that the numbers and disposition of cirri to be variable. More recently, silver-impregnation techniques have been used to study the morphology and morphogenesis of ciliates. The diagnostic value of the silver-line systems of *Aspidisca* spp. and the other features mentioned above will be discussed under separate headings.

Features of taxonomic importance

(a) Habitat

The freshwater species listed by Kahl (1932) include *A. lynceus*, *A. costata*, *A. turrita*, *A. herbicola*, *A. marsupialis* and *A. sulcata*. Earlier Plough (1916) had reported the occurrence of *A. turrita* and *A. costata* in both seawater and freshwater but stated the others, including *A. lynceus*, to be strictly marine species. In fact the original specimens of *A. lynceus* were found in freshwater and the species has since been reported in freshwater sites (Kahl, 1932; Bick, 1972). *A. herbicola* Kahl, 1932 appears to be the only species which is reported to occur in freshwater alone. All other species described to date inhabit the marine environment.

(b) Size

It is known that the size of a ciliate may vary with many factors including rate of growth, concentration of food, kind of food and so on, and is therefore of limited taxonomic value (see Curds, 1975). In the case of *Aspidisca*, while their sizes range from 16 to 150 μm long most species are between 50 and 100 μm long (Fig. 1). Therefore, the exceptionally large size (135–150 μm) of *A. magna* Kahl, 1932 can perhaps justifiably be regarded as diagnostic.

(c) Shape

The typical shape of *Aspidisca* is oval although it generally tends to be more convex on the right than on the left. The outline may be smooth or jagged with spurs or dentations which mostly appear on the left border. The dorsal surface is commonly arched and it may be smooth

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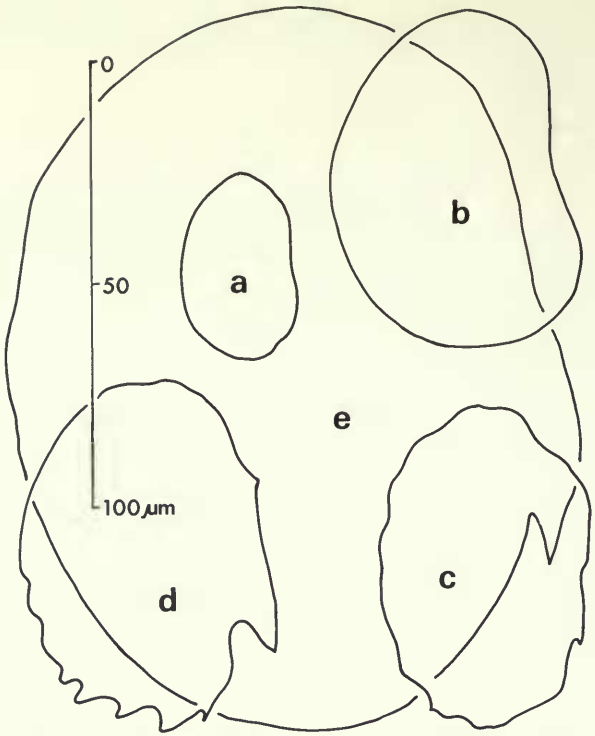

Fig. 1 Sizes of some *Aspidisca* species: (a) *A. polystyla*; (b) *A. magna*; (c) *A. lyncaster* (called *A. leptaspis* in this revision); (d) *A. pulcherrima*; (e) *A. magna* (after Tuffrau, 1964).

or longitudinally marked by indistinct furrows, conspicuous ribs and sometimes a posteriorly directed curving thorn.

Plough (1916) distinguished species primarily by the number of spurs on the left border and indeed, by the relatively crude earlier diagrams, the number of spurs does appear to be the most distinctive feature among the species Plough included (Fig. 2). More specimens with serrated borders have since been studied in greater detail. In many cases the actual number of spurs present and the degree to which they are developed is variable and there is considerable difference between descriptions (Fig. 3). However, a projection from the peristomial area on the left border is found on all species with serrated borders. Thus we do not intend to separate species by the number of peripheral serrations but consider the presence of a 'peristomial spur' diagnostic.

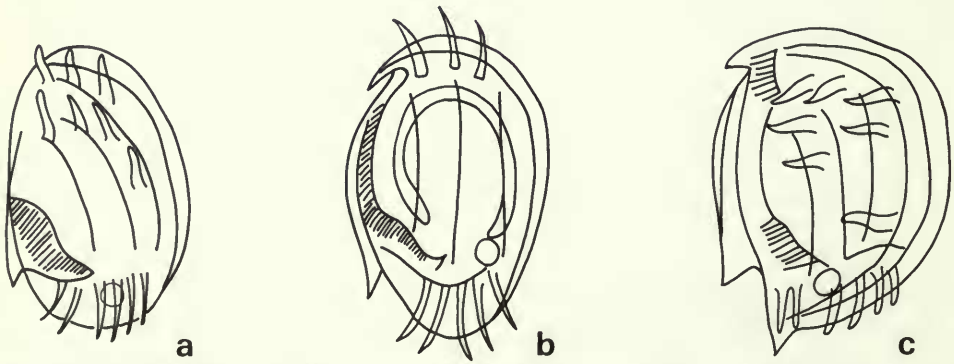

Fig. 2 Ventral surfaces of : (a) *Aspidisca hexeris* (called *A. sedigita* in this revision); (b) *A. lyncaster*; (c) *A. sedigita* (after Plough, 1916).

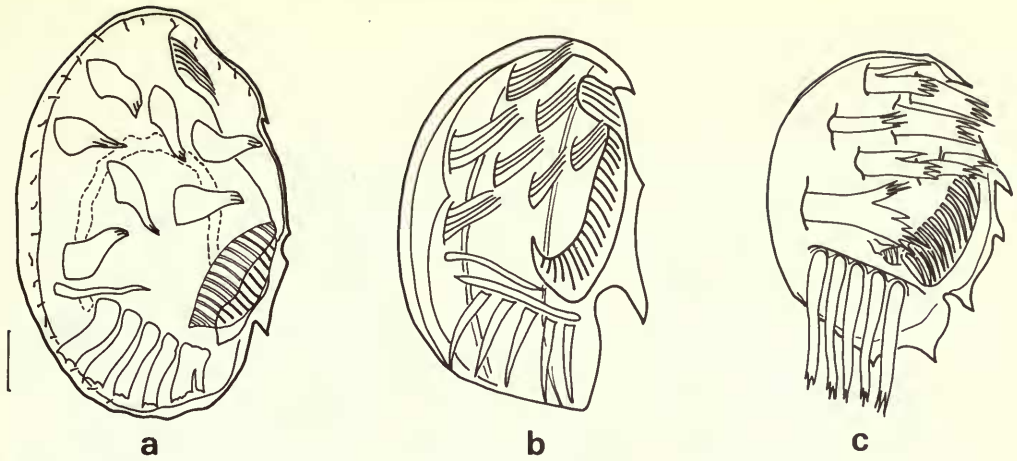

Fig. 3 Ventral surface of *Aspidisca lyncaster* (called *A. leptaspis* in this revision): (a) after Tuffrau, 1964; (b) after Kahl, 1932; (c) after Dragesco, 1960.

(d) Dorsal ribs and thorn

Many workers have reported that the dorsal ribs and thorn noted in several species of *Aspidisca* are inconsistent in size, number and even their presence. Diller (1975) stated that his specimens of *A. costata* usually had six to seven dorsal ribs but the number varied considerably within the three to ten range. Hamm (1964) showed that the size of the dorsal ribs of *A. costata* vary under different growth conditions (Fig. 4). The dorsal thorn of *A. turrita* has also been found to vary in size (Ehrenberg 1838; Claparède & Lachmann 1858). Kahl (1932) stated that this thorn is sometimes missing while Borror (1965) mentioned that a dorsal thorn was present on only some of his specimens of *A. aculeata* (Ehrenberg, 1838) Kahl, 1932. However, in both cases there are insufficient data to be certain that the specimens with and without a dorsal thorn are the same species. In the following keys, the actual presence of ribs, crenated ribs or thorn on the dorsal surface will be used as diagnostic characters but their number and size will be regarded as taxonomically insignificant. More conclusive studies of clonal cultures of *Aspidisca* with dorsal ribs, thorn and peripheral projections would be most valuable, particularly so as variable dorsal ridges and lateral projections have been recently noted (Curds, 1977) in a related hypotrich, *Euplotes aediculatus*.

(e) The adoral zone of membranelles

The genus *Aspidisca* is characterised by a two-part adoral zone of membranelles (AZM) along the left border. The posterior part is a series of 8–20 membranelles lining the peristome which is partially enclosed by the ventral plate and the anterior part is a group of cilia-like structures, two to eight in number, often confined in an indentation of the ventral plate. Kahl (1932) and Dragesco (1965) regarded the configuration of the flap of ventral plate over the buccal cavity as

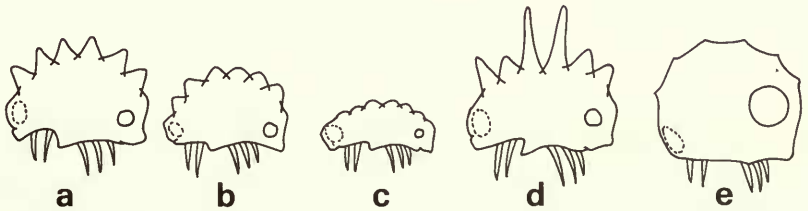

Fig. 4 *Aspidisca costata* showing dorsal ribs of: (a) normal type; (b) overfed form; (c) starved specimen; (d) specimen with extremely high ribs; (e) specimen from an adverse environment (called *A. cicada* in this revision after Hamm, 1964).

a specific character but we find it not sufficiently distinctive to be of significant taxonomic value. The peristome is generally triangular, about one third to half of the body size in length and one fourth to one third in width. In some cases, the peristome extends forward and almost meets the anterior group of ciliary structures which is referred to by different names in the literature and is often regarded as a specialised section of the AZM. We refer to this group of 'cilia' as the anterior ciliary organelle. Diller (1975), who called the organelle a 'tooth', stated that the differentiation of this and the AZM are independent in *A. costata* and suggested that it is equivalent to the I/1 cirrus in *Euplotes* (using the system of Wallengren 1900); this suggestion does not

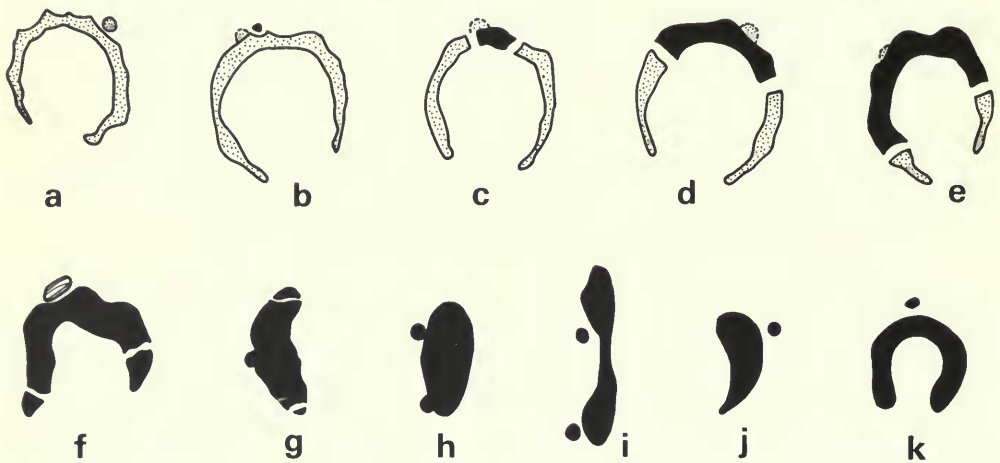

Fig. 5 Some stages of nuclear reorganisation in *Aspidisca lynceus*: (a) the macronucleus of a normal resting individual; (b) an early stage in the formation of the reorganisation band; (c) reorganisation bands completely separated by the central chromatin; (d) nucleus about one-half reorganised; (e) reorganisation about two-thirds complete; (f) the beginning of condensation. Micronucleus in prophase; (g) bands about to disappear; (h) macronucleus fully condensed; (i) constriction of the macronucleus; (j) daughter macronucleus slightly after division; (k) macronucleus of a young daughter individual (after Summers, 1935).

conform with the scheme for *Aspidisca* presented by Tuffrau (1964) (see Fig. 11). The numbers of membranelles in the posterior AZM and of the 'cilia' in the anterior ciliary organelle will be mentioned, if known, in the following descriptions even though they seem to have little diagnostic value.

(f) Nuclear features

It has long been recognised that the nuclei of ciliates are of taxonomic importance. The macronucleus of hypotrichs such as *Euplotes* takes a variety of forms during reorganisation; however, during 'interphase' it is constant and characteristic of the species (see Curds, 1975). Most *Aspidisca* spp. have, like *Euplotes*, a C-shaped or horseshoe-shaped macronucleus and a spherical micronucleus and Summers (1935) described the division and reorganisation of the macronucleus of *A. lynceus* to be comparable to that of *Euplotes*. A band-like macronucleus has been described by Ghosh (1921) and several authors have illustrated horseshoe-shaped macronuclei with dilated centres. These may correspond to two of the divisional stages of the macronucleus of *A. lynceus* as illustrated by Summers (Fig. 5). A small number of species have been found to have two oval or ellipsoid macronuclei. While Tuffrau (1964) suggested that the presence of two macronuclei in *A. major* (Madsen, 1931) Kahl, 1932 might represent a transitional stage, this has not been confirmed and the presence of two macronuclei is used as a diagnostic character in the following keys. Summers (1935) stated that one micronucleus was present in trophic *A. lynceus*, but Borror (1965) found there were one to three micronuclei in his

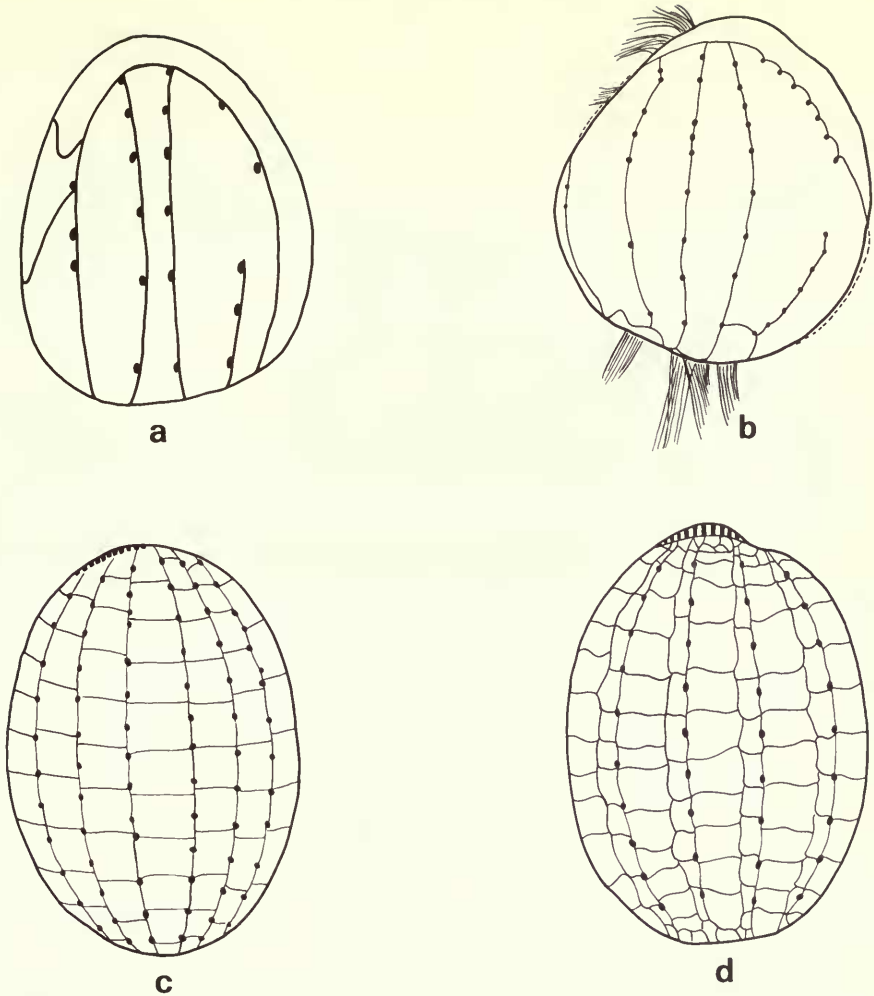

Fig. 6 Dorsal silver-line systems of: (a) *Aspidisca cicada* (after Curds, 1977); (b) *Aspidisca lynceus* (after Klein, 1929); (c) *Euplotes* sp., single-vannus type after Curds, 1975; (d) *Euplotes* sp., double-patella type after Curds, 1975.

specimens of *A. aculeata*. Agamaliev (1967, 1971) observed similar variation in *A. caspica* Agamaliev, 1967 while Dragesco (1954) described *A. hyalina* as possessing four micronuclei. Summers (1935) noted that although the division of the micronucleus is usually initiated when the reorganisation process of the macronucleus is about two thirds complete, it may be much earlier. Dini & Bracchi (1976) who studied the nuclear cycle of *A. aculeata* also found that division of the micronucleus preceded that of the macronucleus. Therefore the presence of two micronuclei may be a transitional state. On the other hand, Dini & Bracchi stated that 'when more micronuclei are present in the same cell, they divide asynchronously'. These data suggest that the number of micronuclei should not be used as a taxonomic criterion until the micronuclear activities of *Aspidisca* are better understood.

(g) Dorsal argyrome

It was hoped that the patterns of the dorsal argyrome or silver-line system of *Aspidisca* would be valuable for specific identification. Unfortunately, only a few workers have described the dorsal silver-line system of the species studied and some have encountered technical difficulties in applying the silver-impregnation methods to this genus although the ventral argyrome and

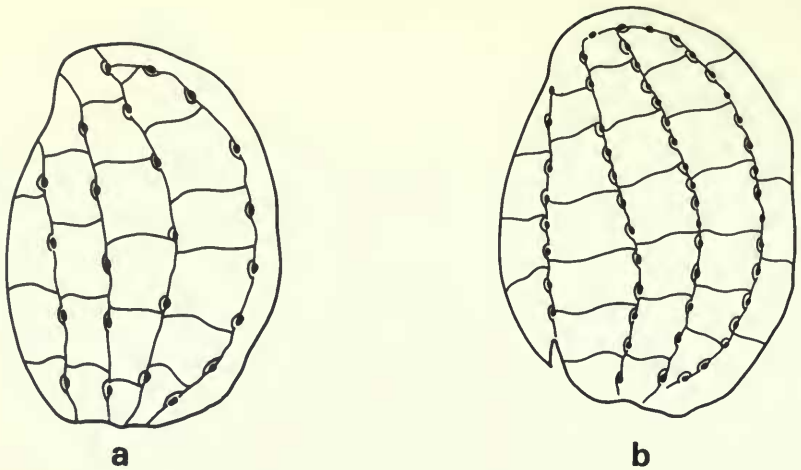

Fig. 7 Dorsal silver-line system of: (a) *Aspidisca aculeata*; (b) *Aspidisca leptaspis* (after Agamaliev, 1974).

cirral bases are usually successfully stained. Even Tuffrau (1964), who pioneered the application of the argyrome patterns for the diagnosis of *Euplotes*, only gave incomplete descriptions of the silver-line systems of *Aspidisca* spp. which he studied. Klein (1929) and Curds (1977) used the dry silver method (see Klein, 1958) to stain *A. lynceus* and *A. cicada* respectively. They found that both of these species have distinctly different argyrome patterns from those described in the genus *Euplotes* (Fig. 6). In neither case did the staining depict any connections between the kineties. However, *A. aculeata* and *A. leptaspis* Fresenius, 1865 have dorsal argyromes similar to those of *Euplotes* with four dorsal kineties connected by single links (Fig. 7). Furthermore, the silver-line systems of *A. polystyla* Stein, 1859 and *A. major* (Madsen, 1931) Kahl, 1932 were described by Tuffrau (1964) as having four kineties with argyrome patterns like those of *Euplotes eurystomus*. Agamaliev (1967, 1971) studied the silver-line system of *A. caspica* and found the dorsal argyrome pattern to be highly variable. He observed single, double and multiple rows of polygons between the kineties in this species and that the number of dorsal cilia was also highly variable (Fig. 8). Recently Gates & Curds (1979) noted that the geometry of the dorsal argyrome in different stocks of the same clone of *Euplotes* varies significantly. Because of the paucity of

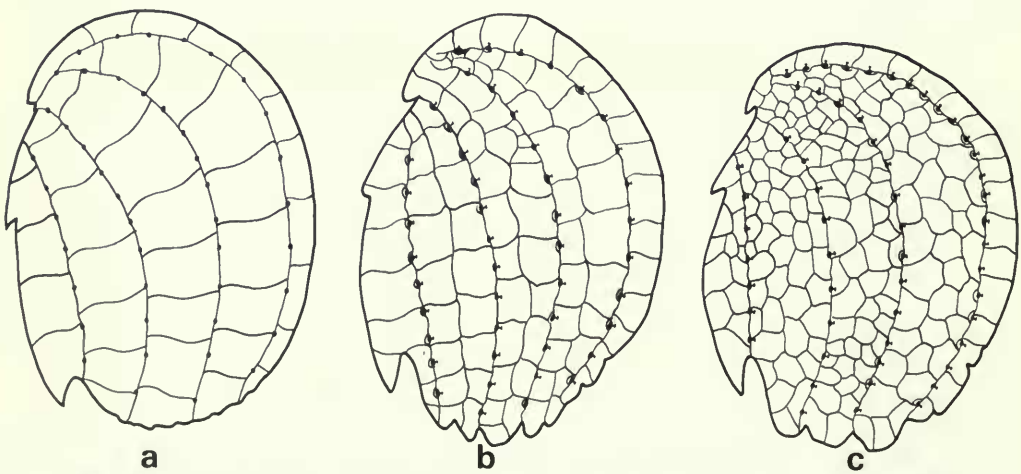

Fig. 8 Dorsal silver-line patterns of *Aspidisca caspica*: (a) after Agamaliev, 1967; (b & c) after Agamaliev, 1971.

data concerning the dorsal argyrome and its reported variability, we have not used it for specific identification but do add information on it when available.

(h) The cirri

We believe that the numbers and arrangements of the cirri on the ventral surface of *Aspidisca* are the most stable diagnostic features. With few exceptions, *Aspidisca* spp. have seven frontoventral and five transverse cirri. Some species have an extra satellite-like frontoventral cirrus making eight in total. Only *A. mutans* Kahl, 1932 and *A. binucleata* Kahl, 1932 have more than eight frontoventral cirri. The extreme left hand cirrus of the five transverse cirri is frequently split, often into three, making seven in all. One species, *A. polystyla*, is consistently found with 11–15 transverse cirri which the present authors regard as a reasonable specific character although it has been suggested (Tuffrau, 1964) that it is the result of three of the original transverse cirri splitting.

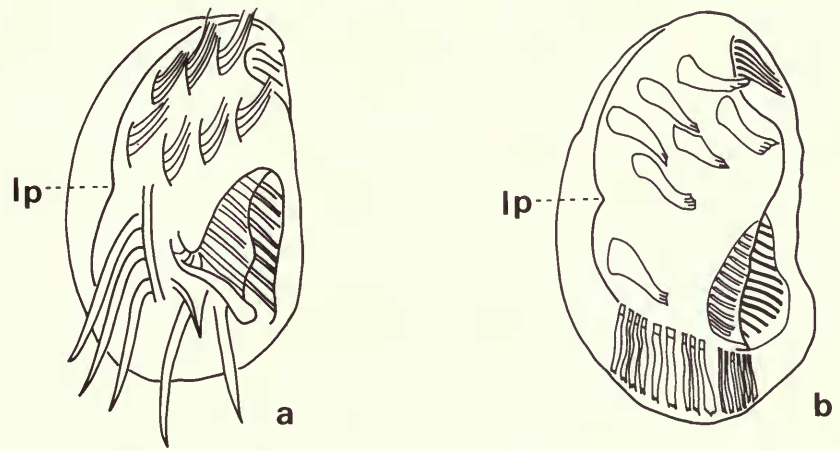

Fig. 9 Cirri arrangement: (a) *Aspidisca lynceus* showing 'lynceus-arrangement' of the frontoventral cirri (after Kahl, 1932); (b) *Aspidisca polystyla* showing 'polystyla-arrangement' of the frontoventral cirri (after Tuffrau, 1964).

The frontoventral cirri appear to be arranged in two basic patterns. One is as in *A. lynceus* where the seven frontoventral cirri are located within the anterior half of the ventral surface, with a row of four cirri running closely along the anterior right border and a row of three nearer the centre (Fig. 9a). The second is as in *A. polystyla* which was the first species to be described with six of the seven frontoventral cirri in the anterior half of the ventral surface, in two groups of three, and the remaining cirrus lying subequatorially in the posterior half of the body close to the transverse cirri (Fig. 9b). These cirri have frequently been referred to as six frontals and one ventral. There is often a low projection ('lp' in Fig. 9) on the inner right border dividing the ventral surface. These two patterns will be referred to as the 'lynceus-arrangement' and the 'polystyla-arrangement'. Where eight frontoventral cirri are observed, one cirrus is invariably satellite-like which does not affect the overall 'polystyla-arrangement' of the other seven cirri. Satellite-like cirri have been shown by Tuffrau (1964) and Deroux & Tuffrau (1965) to have distinct morphogenetic origins. These authors studied the morphogenesis of the cirri of *A. lyncaster* and *A. orthopogon* respectively and numbered the cirri as did Wallengren (1900) for *Euplotes* (Fig. 10a & b). Their system is adopted throughout this revision. Although it is erroneous to regard such cirri as true 'satellites', which many workers have done, the term 'satellite-like', while perhaps misleading, is probably most appropriate. A different morphogenetic pattern for the cirri and the AZM of *A. costata* was presented by Diller (1975) (Fig. 10c).

The location of the transverse cirri is fairly uniform throughout the genus. They are generally just posterior to the peristome in a row curving towards the anterior on the right. In some species,

the three transverse cirri on the right form an almost vertical row slightly apart from the other two cirri. It may be significant that the latter arrangement of the transverse cirri appears to associate with frontoventral cirri in 'lynceus-arrangement' (see Fig. 11).

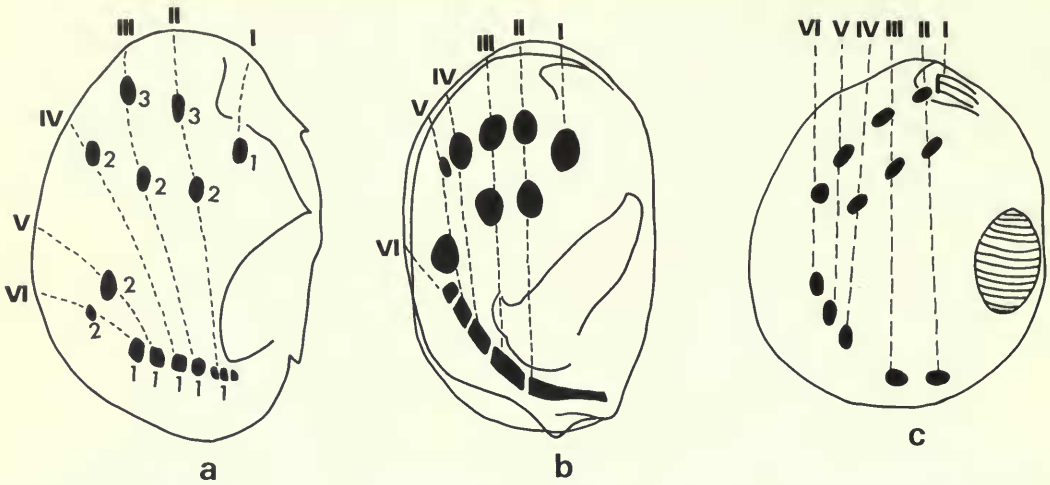

Fig. 10 Numeration of ventral cirri by the Wallengren (1900) system of: (a) *Aspidisca lyncaster* after Tuffrau, 1964 (called *A. leptaspis* in this revision); (b) *A. orthopogon* after Deroux & Tuffrau, 1965; (c) *A. lynceus* after Diller, 1975.

Diagnosis of *Aspidisca*

Small (mostly 50–100 μm) hypotrichs. Body ovoid and rigid. Dorsal and right side convex. Ventral surface flattened. Dorsal surface may be smooth or conspicuously ridged. Left and posterior borders sometimes serrated. AZM in two parts. The posterior part is a system of membranelles lining the peristome while the anterior part (or anterior ciliary organelle) is comprised of two to eight cilia. Seven to eight frontoventral cirri, five to twelve transverse cirri. No marginal or caudal cirri. Macronucleus horseshoe-shaped or in two rounded parts. Mostly marine, few euryhaline.

Systematic description

Keys to the genus *Aspidisca*

The characters selected to separate the species are used in order of their reported stability. The first division of species into groups is based on the number and arrangement of the frontoventral cirri. Further separations are based on the number of transverse cirri, presence of peristomial spur, presence of dorsal ribs and thorn, number of macronuclei and so on. Unless otherwise stated, all species described are marine, the sizes of organisms given in the text refer to their lengths and scales drawn on diagrams indicate 10 μm.

Key to the major groups

1 a	7 or 8 frontoventral cirri	. . . . .	2
b	more than 8 frontoventral cirri	. . . . .	SECTION C p. 27
2 a	frontoventral cirri in 'lynceus-arrangement'	. . . . .	SECTION A p. 9
b	frontoventral cirri in 'polystyla-arrangement'	. . . . .	SECTION B p. 14

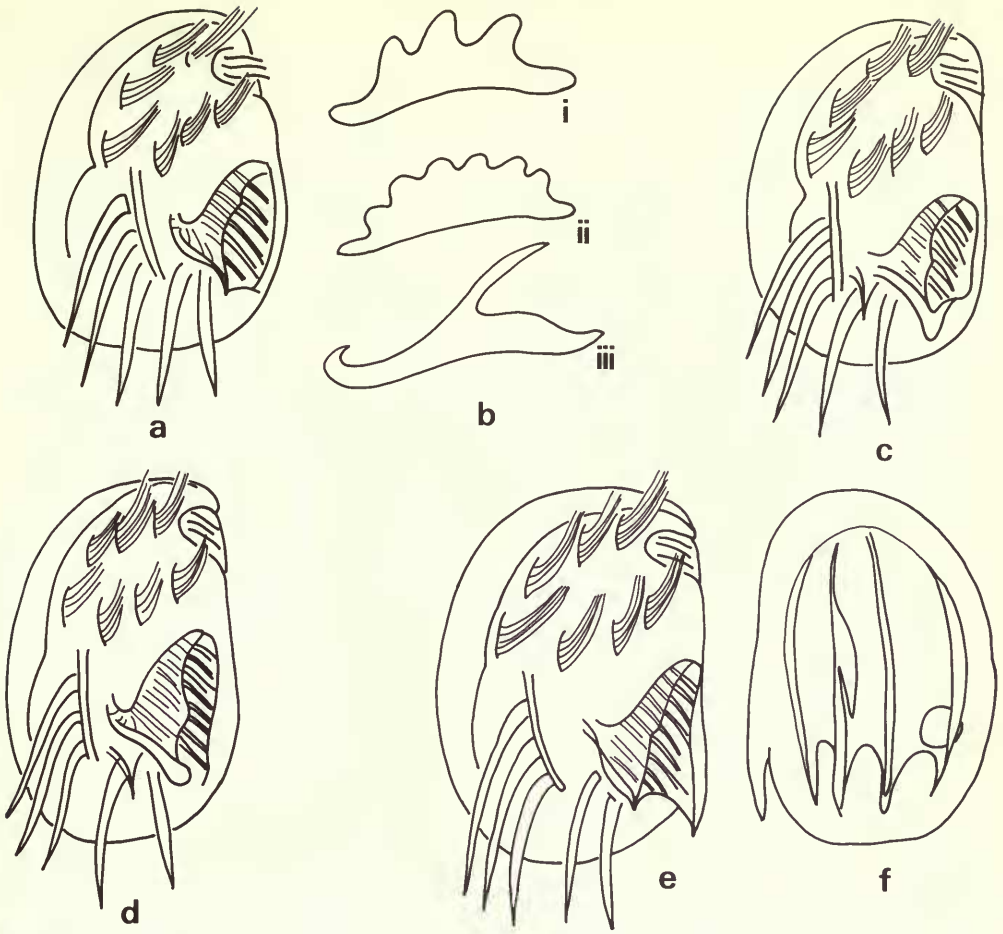

Fig. 11 Four *Aspidisca* species with lynceus-type ventral cirri arrangement (after Kahl, 1932): (a) *A. cicada* (called *A. costata* & *A. sulcata* in Kahl); (b) cross-section of (i) *A. cicada* (called *A. sulcata* in Kahl); (ii) *A. cicada* (called *A. costata* in Kahl), (iii) longitudinal section of *A. turrita*; (c) *A. turrita*; (d) *A. lynceus*; (e) *A. herbicola*, ventral surface; (f) *A. herbicola*, dorsal surface.

Section A

Key to species with frontoventral cirri in 'lynceus-arrangement'

1 a	with peristomial spur	6
b	without peristomial spur	2
2 a	dorsal surface smooth	*A. lynceus*
b	dorsal surface with grooves, ribs and/or thorn.	3
3 a	with dorsal thorn.	*A. turrita*
b	without dorsal thorn	4
4 a	3–10 conspicuous dorsal ribs.	*A. cicada*
b	indistinct dorsal grooves	5
5 a	6 dorsal kineties bearing, from left to right 2 : 7 : 9 : 9 : 7 : 7 cilia	*A. lynceus*
b	5 dorsal kineties bearing, from left to right 3 : 6 : 6 : 3 : 2 cilia	*A. cicada*
6 a	with dorsal thorn.	*A. herbicola*
b	without dorsal thorn	*A. lyncaster*

Aspidisca lynceus (Müller, 1773) Ehrenberg, 1830

Trichoda lynceus Müller, 1773
Aspidisca nana Tucolesco, 1962

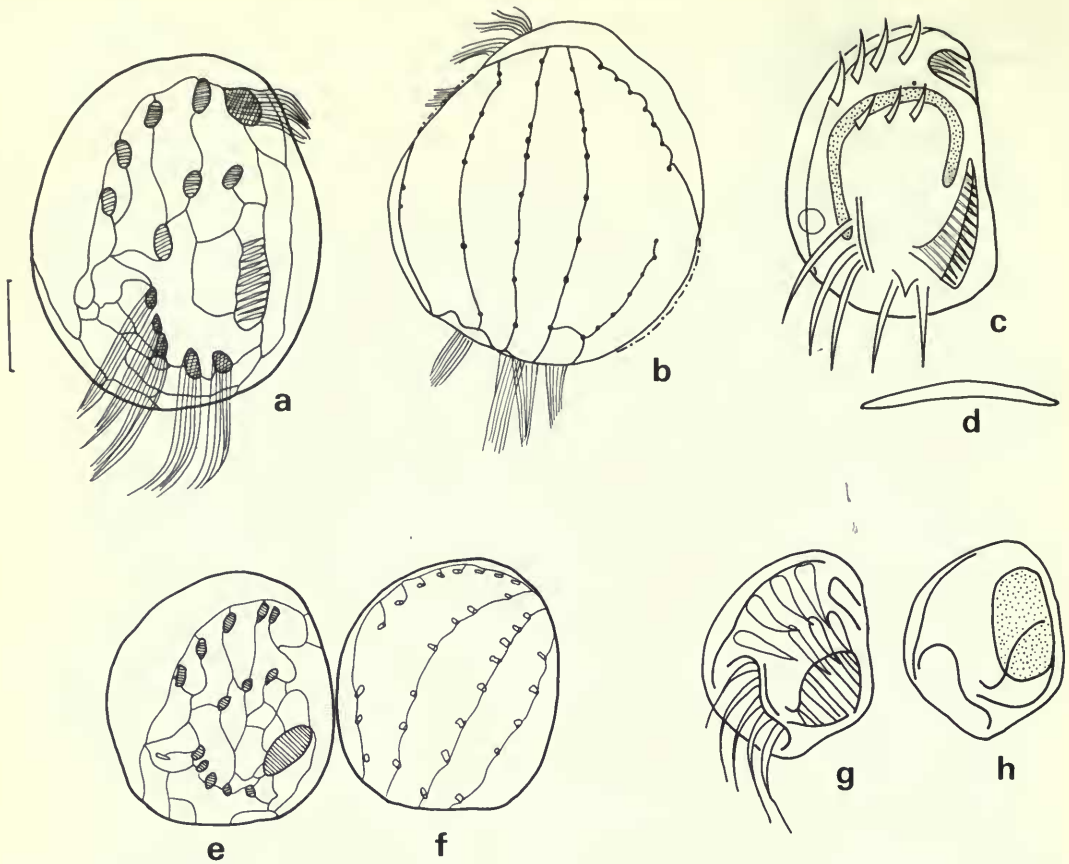

Fig. 12 . *Aspidisca lynceus*: (a & b) ventral & dorsal silver-line systems after Klein, 1929; (c & d) ventral surface & diagrammatic cross-section after Bick, 1972; (e & f) ventral & dorsal silver-line systems after Gelei, 1939; (g & h) ventral view & nucleus (called *A. nana* in Tucolesco, 1962).

This species was first described by Müller (1773) as *Trichoda lynceus* and was transferred to the genus *Aspidisca* by Ehrenberg (1830) as the type species. It is probably the most studied and widespread species of the genus and its general morphology has been described in detail by Claparède & Lachmann (1858), Stein (1859), Kahl (1932), Gelei (1939) and Bick (1972). Klein (1929) was the first to describe the silver-line system stained by the dry-silver method. Gelei (1939) also used the silver-impregnation technique but illustrated a silver-line system different to that shown by Klein. The original specimens were described from freshwater but others have been found in marine and freshwater habitats from various parts of the world.

DIAGNOSIS. *Aspidisca lynceus* (Figs 11d & 12) is a small (30–50 μm) species found in all types of water where decomposition of organic material takes place, frequently in activated sludge. The typical features are oval body with straight left border and convex right border, smooth outline, seven frontoventral cirri, five transverse cirri, 10–15 membranelles in the posterior AZM and three to four cilia in the anterior ciliary organelle, a horseshoe-shaped macronucleus and a spherical micronucelus. The arrangement of the cirri is typical of a group of four species, *A. cicada*, *A. herbicola*, *A. lynceus* and *A. turrita* (Fig. 11). The frontoventral cirri are in two rows, of four and three cirri, near the anterior border; two of the five transverse cirri are immediately posterior to the peristome while the other three are slightly apart on the right and are almost vertically aligned. Kahl (1932) and Bick (1972) have noted a distinct spike-like projection separating the extreme left pair of transverse cirri in *A. lynceus* and this is also found in *A. turrita* (Figs 11c

& d, 12c). A smooth dorsal surface distinguishes *A. lynceus* from *A. cicada* which has dorsal ribs, but Stein (1859) noted three feeble dorsal furrows on his specimens of *A. lynceus*, while Hamm (1964) noted that the ribs of *A. cicada* are sometimes indistinct in which cases the separation of *A. lynceus* from *A. cicada* relied upon the dorsal silver-line system. The silver-line system of *A. lynceus*, according to Klein (1929), consists of two lateral peripheral kineties which meet anteriorly encircling three central longitudinal kineties and a short kinety on their right which extends only to the posterior half of the body. The kineties carry, from left to right, 2 : 7 : 9 : 9 : 7 : 7 cilia (Fig. 12b).

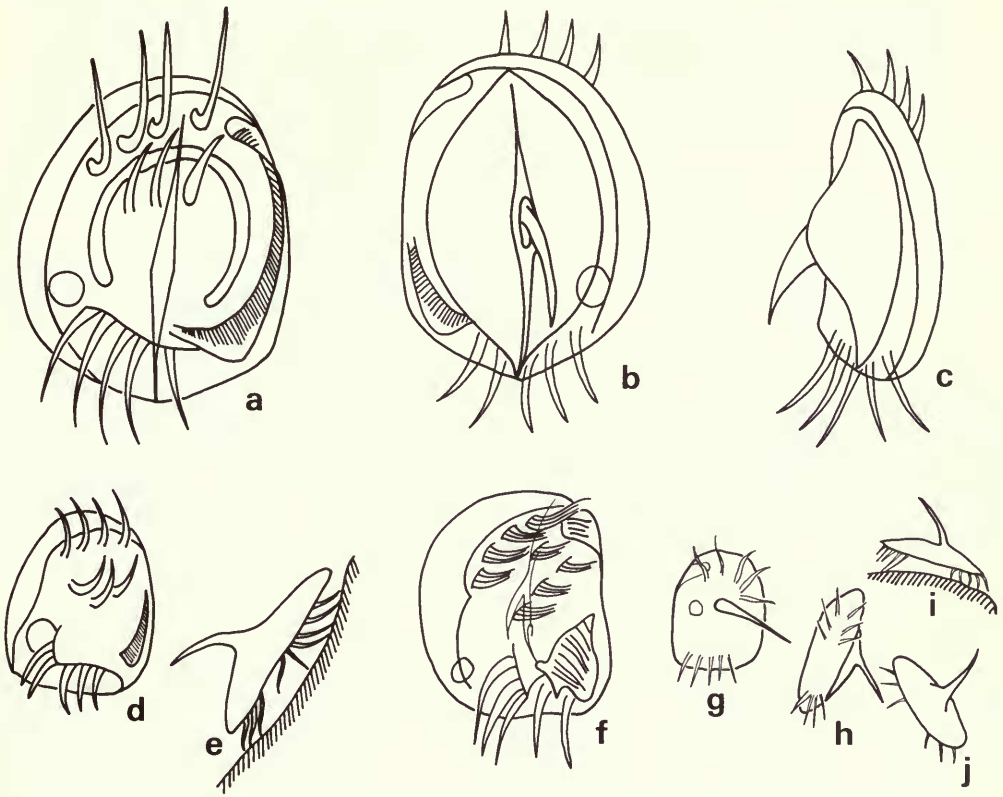

Fig. 13 *Aspidisca turrita*: (a–c) ventral, dorsal & dorsolateral view after Stein, 1859; (d & e) ventral & lateral view after Claparède & Lachmann, 1858; (f) after Kahl, 1932; (g–j) dorsal thorns (called *Euplotes turritus* in Ehrenberg, 1838).

Aspidisca turrita (Ehrenberg, 1838) Claparède & Lachmann, 1858

Euplotes turritus Ehrenberg, 1838

Ehrenberg (1838) first discovered this species, which is characterised by the presence of a dorsal thorn, among seaweeds in Berlin and later in freshwater together with *A. lynceus*. He named this organism *Euplotes turritus* but Claparède & Lachmann (1858) transferred it to the genus *Aspidisca* and emended the specific name to *turrita*. The latter authors noted that the dorsal thorn on their specimens found near Berlin was more prominent than that reported by Ehrenberg. The species was redescribed by Stein (1859), Plough (1916) and Kahl (1928, 1932). Kahl (1932) noted that its shape and ciliature are completely identical to those of *A. lynceus* and that there may be ribs as well as a thorn on the dorsal surface which itself may vary in size or be missing. Further studies may prove the dorsal thorn to be a transitional appendage, in which case *A. turrita* should be regarded as a synonym of *A. lynceus*.

DIAGNOSIS. *Aspidisca turrita* (Figs 11c & 13) is a euryhaline species and its morphology is almost identical to the type species *A. lynceus*. It is small (20–30 μm), the body is oval but convex on the right and the outline is smooth. There are seven frontoventral cirri in 'lynceus-arrangement' and, as in *A. lynceus*, two of the five transverse cirri are found posterior of the peristome separated by a 'spike'. The other three transverse cirri are aligned almost vertically near the right border. The macronucleus is C-shaped. A curved, pointed dorsal thorn distinguishes this from the type species.

Aspidisca cicada (Müller, 1786) Claparède & Lachmann, 1858

Trichoda cicada Müller, 1786
Coccudina cicada Bory, 1827
Coccudina crassa Dujardin, 1841
Aspidisca costata (Dujardin, 1841) Stein, 1859
Aspidiscopsis bengalensis Ghosh, 1921
Aspidisca marsupialis Penard, 1921
Aspidisca sulcata Kahl, 1932
Aspidisca costata f. *tetracirrata* Tucolesco, 1962

The taxonomic history of this species is one of confusion and misidentifications. Brown (1966) studied the species and subsequently (Brown, 1968) gave a complete historical account of the nomenclature of the species but the confusion remained. A recent account and redescription of the species was given by Curds (1977).

Briefly, the original freshwater specimens were described by Müller (1786) and named *Trichoda cicada* which Bory (1827) then transferred to the genus *Coccudina*. Claparède & Lachmann (1858) placed *T. cicada* Müller in the genus *Aspidisca*. Stein (1859) first synonymised *Coccudina costata* Dujardin, 1841 with *Aspidisca cicada* Claparède & Lachmann, 1858. However, the dorsal ribs of the former species were described as being crenated while those of the latter species were said to be smooth. Later workers including Plough (1916), Kahl (1932), Hamm (1964), Bick (1972) and Diller (1975) perpetuated the error and described *A. cicada* (Müller, 1786) Claparède & Lachmann, 1858 under the name *A. costata* (Dujardin, 1841) Stein, 1859. Borror (1972) also listed *A. cicada* as a synonym of *A. costata* and *Trichoda cicada* as a synonym of *A. lynceus*.

DIAGNOSIS. *Aspidisca cicada* (Fig. 14) is a small (20–45 μm) euryhaline species similar to the type species *A. lynceus* and equally widely distributed. The oval body is convex on the right and there are seven frontoventral and five transverse cirri. The frontoventral cirri are in 'lynceus-arrangement' and a projection separating the second and third transverse cirri from the left has been noted by Bick (1972) and Curds (1977). The body outline is smooth but the peristome sometimes form a 'swelling' at the posterior left. There are about eight membranelles in the posterior AZM and three anterior cilia. The dorsal surface is conspicuously ridged by longitudinal ribs varying in size and number (within the three to ten range). The macronucleus is C-shaped and the micronucleus is at its anterior left. The dorsal silver-line system consists of two central longitudinal kineties and on their right a short kinety extending only to the posterior third of the body, encircling these are two outer kineties which runs along the periphery and meet anteriorly. The five kineties, from left to right, carry 3 : 6 : 6 : 3 : 2 cilia.

Aspidisca herbicola Kahl, 1932

This species has been described once briefly and it is the only species that has not yet been found in marine habitats.

DIAGNOSIS. *Aspidisca herbicola* (Fig. 11e & f) is a small (50 μm) freshwater species. The peristomial spur and the four dorsal ribs, one bearing a thorn, distinguish this from the type species. The seven frontoventral cirri are in 'lynceus-arrangement'. The transverse cirri are arranged exactly like those of *A. lynceus* except that the two cirri on the left are not separated by a 'spike'. There are about ten membranelles in the posterior AZM and three anterior cilia.

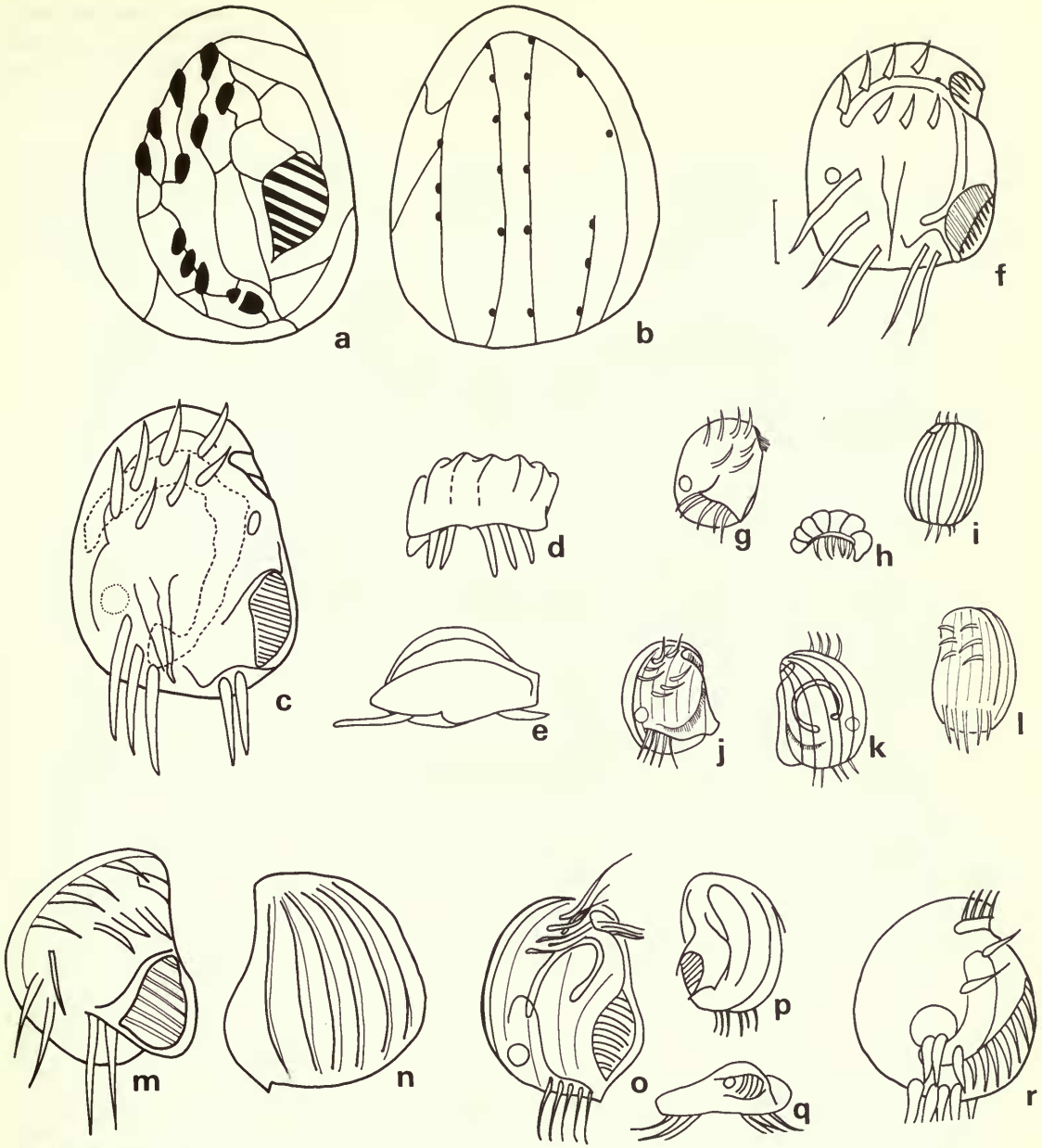

Fig. 14 *Aspidisca cicada*: (a–e) after Curds, 1977; (f) after Bick, 1972 (called *A. costata*); (g–i) after Claparède & Lachmann, 1858; (j–k) after Stein, 1859 (called *A. costata*); (l) after Dujardin, 1841 (called *Coccudina crassa*); (m–n) after Tucolesco, 1962 (called *A. costata* f. *tetracirrata*); (o–q) after Penard, 1921 (called *A. marsupialis*); (r) after Ghosh, 1921 (called *Aspidiscopsis bengalensis*).

Aspidisca lyncaster (Müller, 1779) Stein, 1859

Trichoda lyncaster Müller, 1779
Kerona lyncaster Müller, 1786

This species was first briefly described as *Trichoda lyncaster* by Müller in 1779 and later (1786) he transferred it to the genus *Kerona*. Stein (1859), by fixing the animals, gave a more detailed

description of the specimens collected from seawater of Stralsundt, and later from Travemünde. The species was transferred to the genus *Aspidisca* by Stein in 1859. Plough (1916) redescribed the species in his work but later workers, including Kahl (1932), Dragesco (1960) and Tuffrau (1964), described organisms under the name *A. lyncaster*, which the present authors would regard as *A. leptaspis*.

DIAGNOSIS. *Aspidisca lyncaster* (Fig. 15) is a small (30–50 μm) species. It is almost egg-shaped, slightly pointed posteriorly. On the left border there is a conspicuous peristomial spur and a smaller anterior projection. There are seven frontoventral cirri in 'lynceus-arrangement' which distinguishes this species from *A. leptaspis*, five transverse cirri, an extensive peristome and two to three cilia in the anterior ciliary organelle. The dorsal surface is marked by three longitudinal ridges and the macronucleus is horseshoe-shaped.

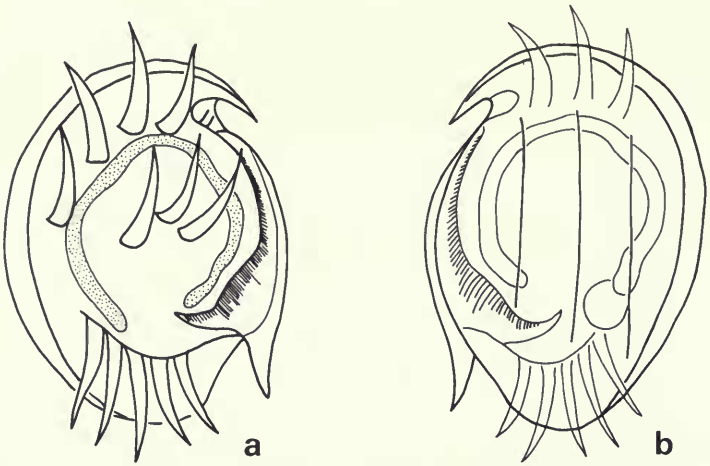

Fig. 15 *Aspidisca lyncaster*: (a) ventral surface; (b) dorsal surface (after Stein, 1859).

Section B

Key to species with frontoventral cirri in 'polystyla-arrangement'

1 a	7 frontoventral cirri	2
b	8 frontoventral cirri	11
2 a	5–7 transverse cirri	3
b	10–15 transverse cirri	***A. polystyla***
3 a	with peristomial spur	8
b	without peristomial spur	4
4 a	dorsal surface smooth	5
b	dorsal surface with ridges, ribs and/or thorn	6
5 a	2 macronuclei	***A. major***
b	single macronucleus	***A. steini***
6 a	dorsal surface with ribs but without thorn	7
b	dorsal surface with ribs and a thorn	***A. aculeata***
7 a	dorsal ribs crenated	***A. tuberosa***
b	dorsal ribs not crenated	***A. polypoda***
8 a	dorsal surface with ribs and a thorn	***A. dentata***
b	dorsal surface without thorn	9
9 a	120–150 μm	***A. magna***
b	50–100 μm	10

10 a	2 macronuclei	*A. fusca*
b	single macronucleus	*A. sedigita*
11 a	without peristomial spur (with V/3 cirrus)	*A. orthopogon*
b	with peristomial spur (with VI/2 cirrus)	12
12 a	dorsal surface with smooth ridges	*A. leptaspis*
b	dorsal surface with crenated ribs	*A. pulcherrima*

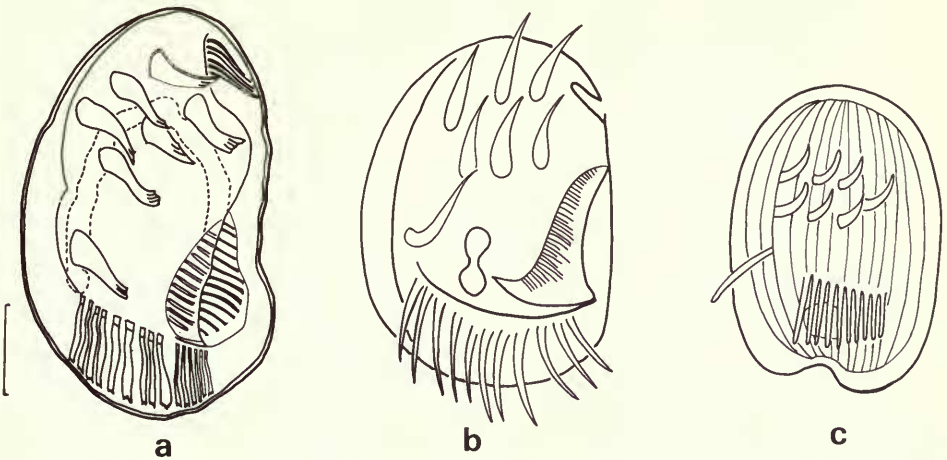

Fig. 16 *Aspidisca polystyla*: (a) after Tuffrau, 1964; (b) after Stein, 1859; (c) after Pereyaslawzewa, 1886 (called *A. plana*).

Aspidisca polystyla Stein, 1859

Aspidisca plana Pereyaslawzewa, 1886

The original study of this species by Stein (1859) was very detailed and he characterised the species by the presence of a large number of transverse cirri. Most of the original specimens had 10–11 transverse cirri but some had 12, up to 15 have been observed in later studies. Plough (1916), Kahl (1932) and Tuffrau (1964) all described the species and Tuffrau mentioned the silver-line system. Dragesco (1963) described an organism which he regarded as *A. polystyla* possessing only five transverse cirri, but the present authors consider this specimen to be *A. steini*.

Diagnosis. *Aspidisca polystyla* (Fig. 16) is a small (40–50 μm) species characterised by 10–15 transverse cirri. The body outline is smooth and the dorsal surface is marked by three longitudinal ridges. The arrangement of the seven frontoventral cirri is diagnostic: two rows of three cirri are found near the anterior while one cirrus is found near the transverse group. There are about 15 membranelles in the posterior AZM and two to six anterior cilia. The macronucleus is horseshoe-shaped but no micronucleus has been observed. The dorsal silver-line system was described by Tuffrau (1964) as consisting of four kineties with hexagonal links as in *Euplotes eurystomus* but no illustration was provided.

Aspidisca major (Madsen, 1931) Kahl, 1932

Onychaspis (*Aspidisca*) *steini* var. *major* Madsen, 1931
Aspidisca steini var. *major* (Madsen, 1931) Kahl, 1932
Aspidisca major var. *faurei* Dragesco, 1960

Madsen (1931) described this species as *Onychaspis* (*Aspidisca*) *steini* var. *major* which was distinguished from *A. steini* Buddenbrock, 1920 by its larger size. The description was brief and there was no mention of nuclei. Kahl (1932) redescribed this species as *Aspidisca* (*Onychaspis*) *steini* var. *major* and listed *Aspidisca major* Madsen (?) with two macronuclei as a separate species.

Kahl separated *A. steini* var. *major* and *A. major* by the difference in number and disposition of the anterior cilia. Tuffrau (1964) later described *A. major* Madsen (?) which is almost identical to the *Onychaspis* (*Aspidisca*) *steini* var. *major* of Madsen (1931) and had two macronuclei. Tuffrau noted that the two macronuclei were connected by a nuclear membrane, and in *A. major* var. *faurei* Dragesco, 1960 they appear to be joined more completely. However, in both cases there are two distinct nuclear elements.

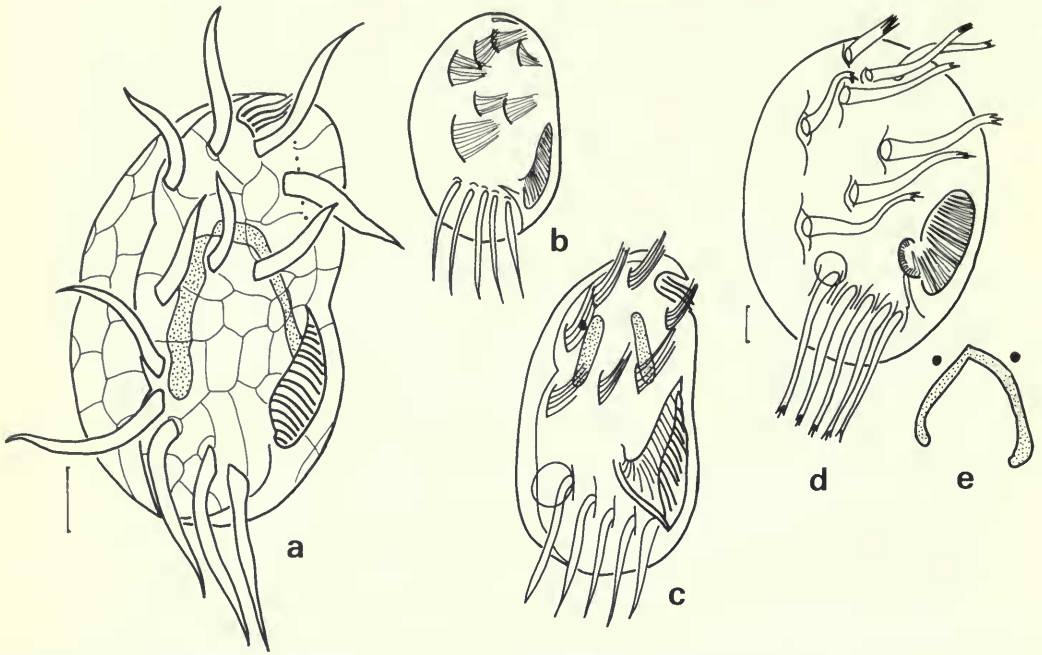

Fig. 17 *Aspidisca major*: (a) after Tuffrau, 1964; (b) after Madsen, 1931 (called *Onychaspis* (*Aspidisca*) *steini* var *major*); (c) after Kahl, 1932; (d) after Dragesco, 1960 (called *A. major* var *faurei*); (e) nuclear features after Dragesco, 1960.

DIAGNOSIS. *Aspidisca major* (Fig. 17) is a medium size (60–100 μm) oval species with perfectly smooth borders and a smooth dorsal surface. The seven frontoventral cirri are in 'polystyla-arrangement' and the five transverse cirri are long. The group of one to four anterior cilia is found just anterior of the II/3 cirrus as in *A. steini*. The peristome, with about 15 membranelles in the posterior AZM, is small relative to the body size. There are two ellipsoid macronuclei which may be connected by a nuclear membrane. The dorsal silver-line system consists of four rows of sensory bristles with transverse links forming regular polygons as in *A. polystyla* and *Euplotes eurystomus* (Tuffrau, 1964).

Aspidisca steini Buddenbrock, 1920

Aspidisca glabra Kahl, 1928
Aspidisca hyalina Dragesco, 1954
[*Aspidisca polystyla* Stein; Dragesco, 1963 Misidentification]

The original specimens of this species were found in a marine aquarium in Germany. Buddenbrock (1920) pointed out the possibility of it being a variety of *A. polystyla* Stein which differs only in having many more transverse cirri. However, it was later found that the two species could be distinquished by their silver-line systems. Kahl (1932) inadequately redescribed the species, but Borror (1963) found an organism of similar shape and ciliature in N. America which he identified as *A. steini* and gave data concerning its size, micronucleus and dorsal kineties for the first time.

DIAGNOSIS. *Aspidisca steini* (Fig. 18) is a small (30–35 μm) species characterised by its smooth outline and smooth dorsal surface. The seven frontoventral cirri are in 'polystyla-arrangement' and the extreme left cirrus of the five transverse cirri may be double-based or split into two making six transverse cirri. There are eight to nine membranelles in the posterior AZM and the anterior ciliary organelle containing two to four cilia is positioned just anterior to the II/3 cirrus. The macronucleus is C-shaped and the spherical micronucleus is located on its left. There are five dorsal kineties carrying, from left to right, 2 : 4 : 5 : 5 : 4 cilia respectively.

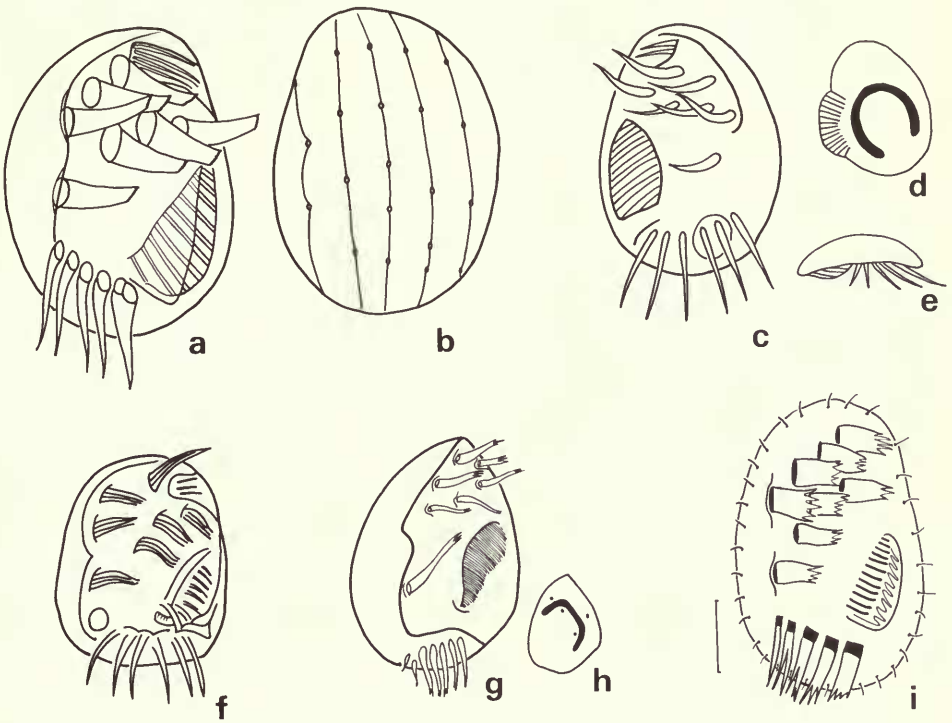

Fig. 18 *Aspidisca steini*: (a & b) ventral surface & dorsal silver-line system after Borror, 1963; (c–e) after Buddenbrock, 1920; (f) after Kahl, 1928 (called *A. glabra*); (g–h) after Dragesco, 1954 (called *A. hyalina*); (i) after Dragesco, 1963 (called *A. polystyla*).

Aspidisca aculeata (Ehrenberg, 1838) Kahl, 1932

Euplotes aculeata Ehrenberg, 1838
Onychaspis aculeata Manseld, 1923

Ehrenberg (1838) first discovered this small species with a dorsal 'backward curving hook' in seawater at Kiel which he called *Euplotes aculeata* Ehrenberg, 1838. The original diagrams were crude and practically identical to those of *Euplotes turritus* Ehrenberg, 1838. Mansfeld (1923) found in an aquarium in Berlin a hypotrich, *Onychaspis aculeata*, with a dorsal thorn similar to *Aspidisca turrita* (Ehrenberg, 1838) Claparède & Lachmann, 1858 but differing in having dorsal ribs as well as a thorn. Kahl later (1932) identified it as *Euplotes aculeata* Ehrenberg and transferred it to the genus *Aspidisca*. Borror (1965) and Agamaliev (1974) redescribed the species in greater detail, stained the silver-line system and noted up to three micronuclei. The arrangement of the frontoventral cirri of *Onychaspis aculeata* illustrated by Mansfeld appears to be different from the two usual patterns but we consider the illustrations by the later authors more reliable.

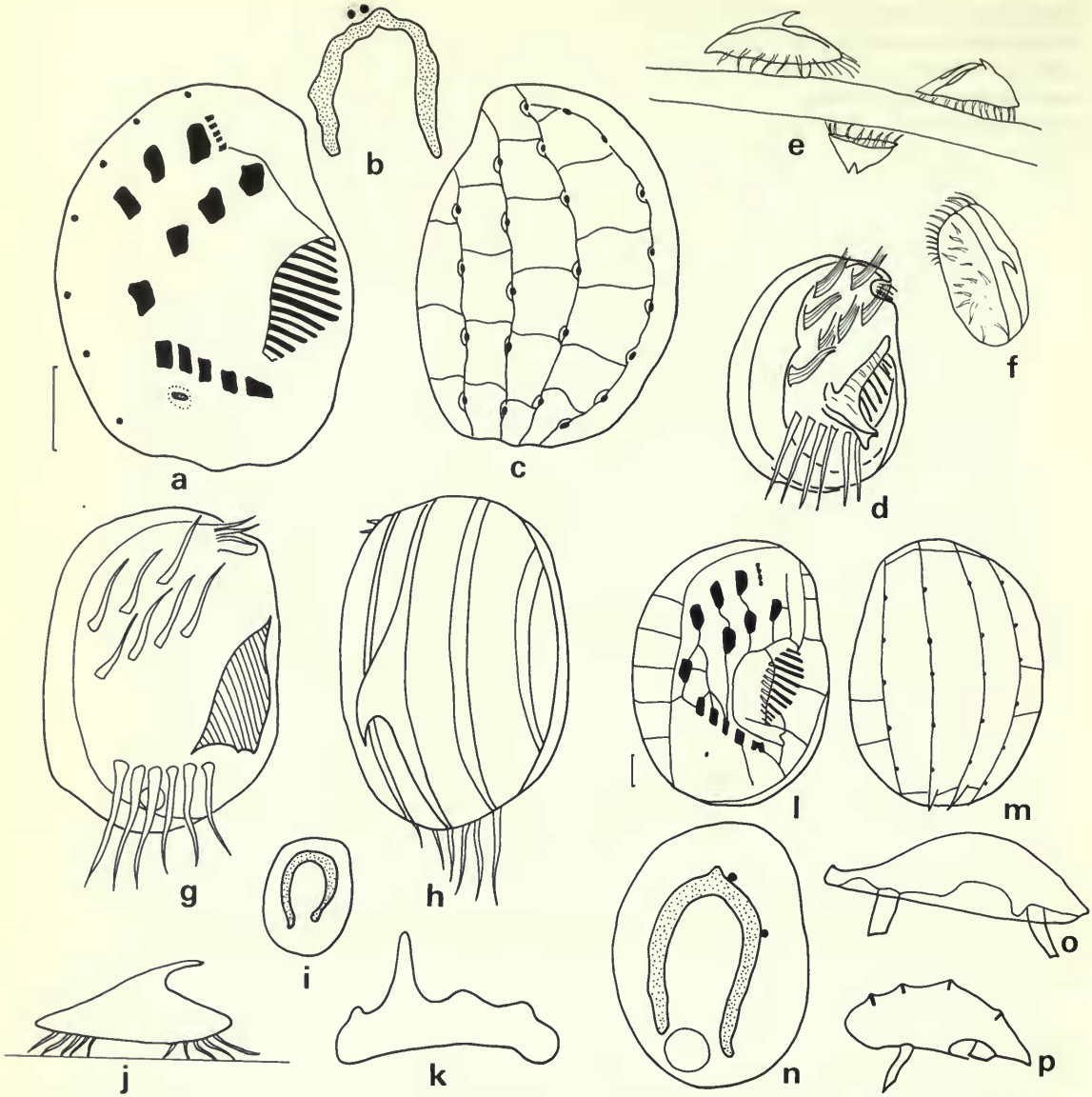

Fig. 19 *Aspidisca aculeata*: (a–c) after Agamaliev, 1974; (d) after Kahl, 1932; (e–f) after Ehrenberg, 1838 (called *Euplotes aculeata*); (g–k) after Mansfeld, 1923 (called *Onychaspis aculeata*); (1–p) after Borror, 1965.

DIAGNOSIS. *Aspidisca aculeata* (Fig. 19) is a small (30–50 μm) species with seven frontoventral cirri in 'polystyla-arrangement' which distinguishes it from *Aspidisca turrita*, and five or six transverse cirri. The body is oval, slightly convex on the right, and the outline is smooth. Dorsally there are four ribs, the second from the left of which carries a thorn. The macronucleus is C-shaped and one to three micronuclei may be found by its anterior left. The peristome is average in size with about ten membranelles in the posterior AZM and there are three to five anterior cilia. The silver-line system, according to Agamaliev (1974), consists of five dorsolateral kineties with single cross-links, and the four dorsal kineties carry, from left to right, 4 : 5 : 6 : 8 cilia respectively; while Borror (1965) found no lateral kineties and the four dorsal kineties carry, from left to right, 5 : 5 : 5 : 6 cilia respectively and a few cross-links were noted.

Aspidisca tuberosa Kahl, 1932

Oxytricha cicada Ehrenberg, 1838
Coccudina costata Dujardin, 1841

The description of this species by Kahl (1932) is brief but the ventral ciliature and the crenated dorsal ribs are clearly illustrated. A small, smooth-bordered hypotrich with crenated ribs was described as *Oxytricha cicada* by Ehrenberg, 1838, and was considered by Dujardin (1841) to be similar to *Coccodina costata*. Since the specific name *cicada* is preoccupied, the correct combination for this taxon should be *Aspidisca costata*. But, due to a long history of misuse of this combination when describing *A. cicada* (Müller, 1786) Claparède & Lachmann, 1858 (see p. 12), the present authors refrain from making this emendation.

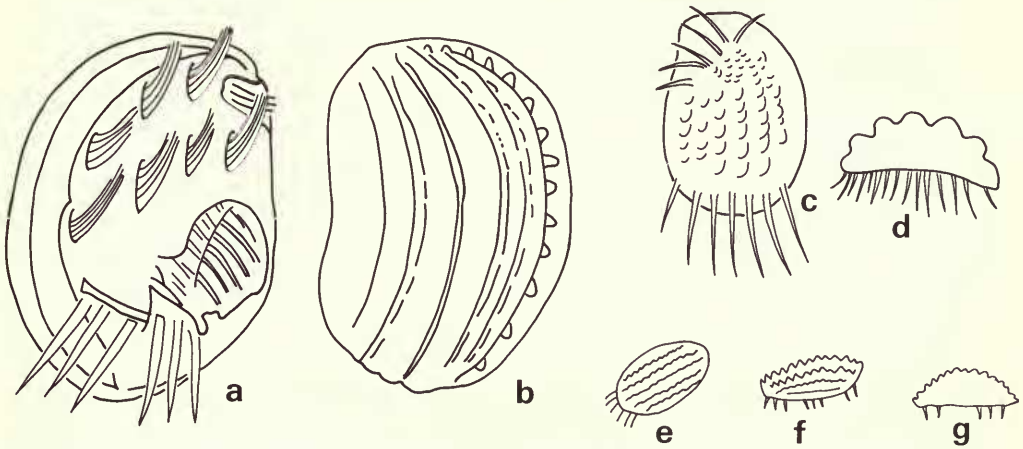

Fig. 20 *Aspidisca tuberosa*: (a–b) after Kahl, 1932; (c–d) after Dujardin, 1841 (called *Coccudina costata*); (e–g) after Ehrenberg, 1838 (called *Oxytricha cicada*).

DIAGNOSIS. *Aspidisca tuberosa* (Fig. 20) is a small (30–35 μm) species characterised by four to six crenated sharp dorsal ribs. Its body shape is typical of the genus, oval and convex on the right. There are seven frontoventral cirri in 'polystyla-arrangement', six transverse cirri, three cilia in the anterior ciliary organelle and ten membranelles in the posterior AZM.

Aspidisca polypoda (Dujardin, 1841) Kahl, 1932

Coccudina polypoda Dujardin, 1841
Aspidisca andreewi Mereschowsky, 1878
Aspidisca polystyla var *maxima* Gourret & Roeser, 1886
Aspidisca quadrilineata Kahl, 1932

This species characterised by seven or eight conspicuous dorsal ribs was first described by Dujardin (1841). Kahl (1932) clearly illustrated the dorsal ribs and the ventral cirri of specimens from Heligoland and transferred the species to the genus *Aspidisca*. Dragesco (1960) described somewhat larger organisms from Roscoff which he identified as *A. polypoda* but made no mention of the characteristic dorsal ribs. The latter author also described the nuclei and mentioned that 'le tégument de ce cilié montre une fine structure superficielle, constituant un véritable réseau à mailles fines' but presented no diagrams of these. As in the case of *A. lynceus* and *A. cicada*, a distinctive silver-line system would be a more precise feature for separating *A. polypoda* from *A. steini* rather than just the presence of dorsal ribs.

DIAGNOSIS. *Aspidisca polypoda* (Fig. 21) is a small (30–55 μm) species with seven or eight distinctive dorsal ribs which distinguishes it from *A. steini*, and the 'polystyla-arrangement' of the seven frontoventral cirri distinguishes it from *A. cicada*. Six transverse cirri are generally

noted. The peristome is small with 8–15 membranelles in the posterior AZM and there are three to four anterior cilia. The macronucleus is described as a horseshoe-shaped opening towards the posterior right and the spherical micronucleus is found in the opening (Dragesco, 1960).

Aspidisca dentata Kahl, 1928

This species has been described only by Kahl (1928, 1932) and it was found extensively in Oldesloe, Kiel and the North Sea but not in large numbers.

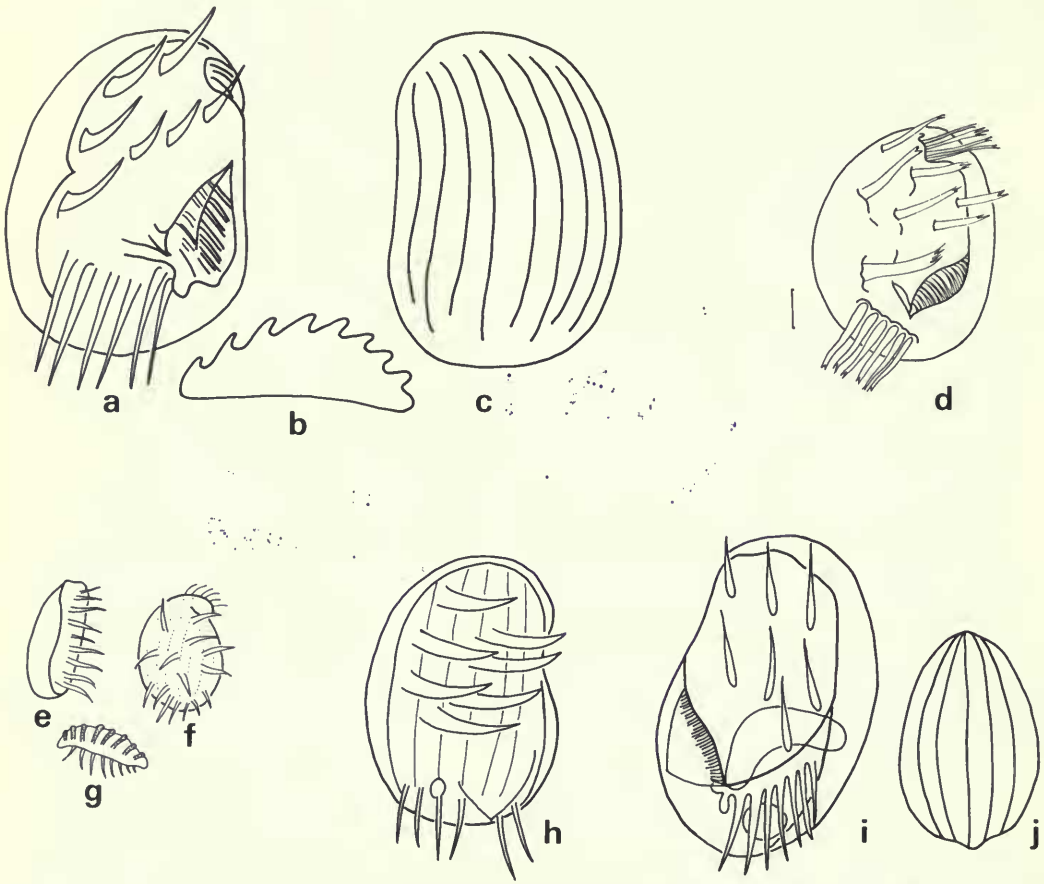

Fig. 21 *Aspidisca polypoda*: (a–c) after Kahl, 1932; (d) after Dragesco, 1960; (e–g) after Dujardin, 1841 (called *Coccudina polypoda*); (h) after Mereschkowsky, 1878 (called *A. andreewi*); (i–j) after Gourret & Roeser, 1886 (called *A. polystyla* var *maxima*).

DIAGNOSIS. *Aspidisca dentata* (Fig. 22) is a small (20–40 μm) species. It has four dorsal ribs, one of which bears a thorn. There are seven frontoventral cirri in 'polystyla-arrangement', six transverse cirri, six to ten membranelles in the posterior AZM and four anterior cilia. The presence of a peristomial spur separate this from the almost identical species *Aspidisca aculeata*.

Aspidisca magna Kahl, 1932

Aspidisca pelvis Delphy, 1938
Aspidisca maxima Vacelet, 1961 (see Vacelet, 1961*b*)

The original description of this species by Kahl (1932) was inadequate as only six to eight specimens were observed. However, its large size is distinctive. Tuffrau (1964) described an equally large

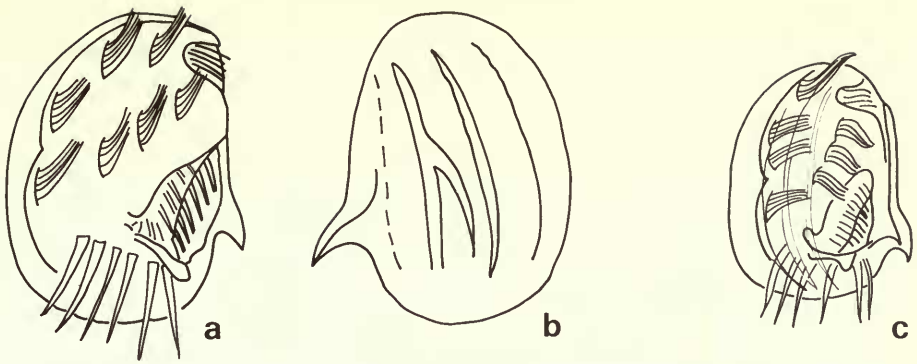

Fig. 22 *Aspidisca dentata*: (a & b) ventral & dorsal surface after Kahl, 1932; (c) ventral surface after Kahl, 1928.

species which also possessed a peristomial spur and this he identified as *A. magna*. Although Tuffrau used silver-impregnation techniques, only a vague description of the dorsal silver-line system was given.

DIAGNOSIS. *Aspidisca magna* (Fig. 23) is the largest (135–157 μm) species described. The body is broadly oval and its outline is broken only by a broad conspicuous peristomial spur. There are four ribs on the dorsal surface and the central ones of these are higher than the lateral ones. The seven frontoventral cirri are in 'polystyla-arrangement' and there are five or six transverse cirri. The peristome is small in proportion to the body size with about 20 membranelles in the posterior

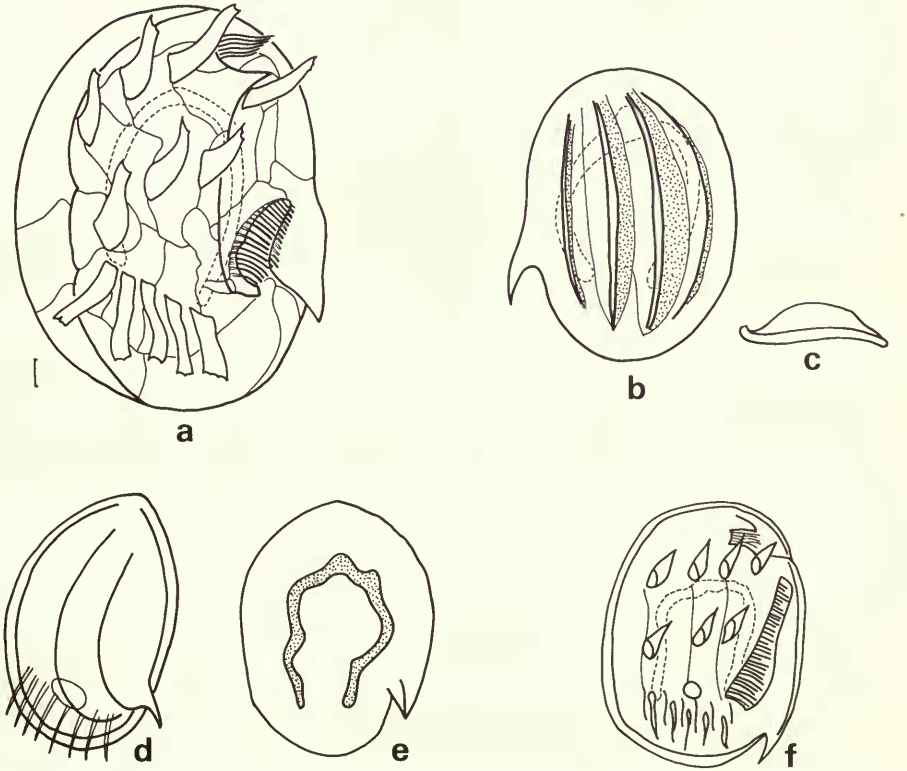

Fig. 23 *Aspidisca magna*: (a) after Tuffrau, 1964; (b–c) after Kahl, 1932; (d–e) after Delphy, 1938 (called *A. pelvis*); (f) after Vacelet, 1961*b* (called *A. maxima*).

AZM and there are six anterior cilia. The macronucleus is a slim horseshoe but no micronucleus has been noted. The dorsal argyrome pattern is described as 'classic' with four kinety meridians joined by simple transverse links (Tuffrau, 1964).

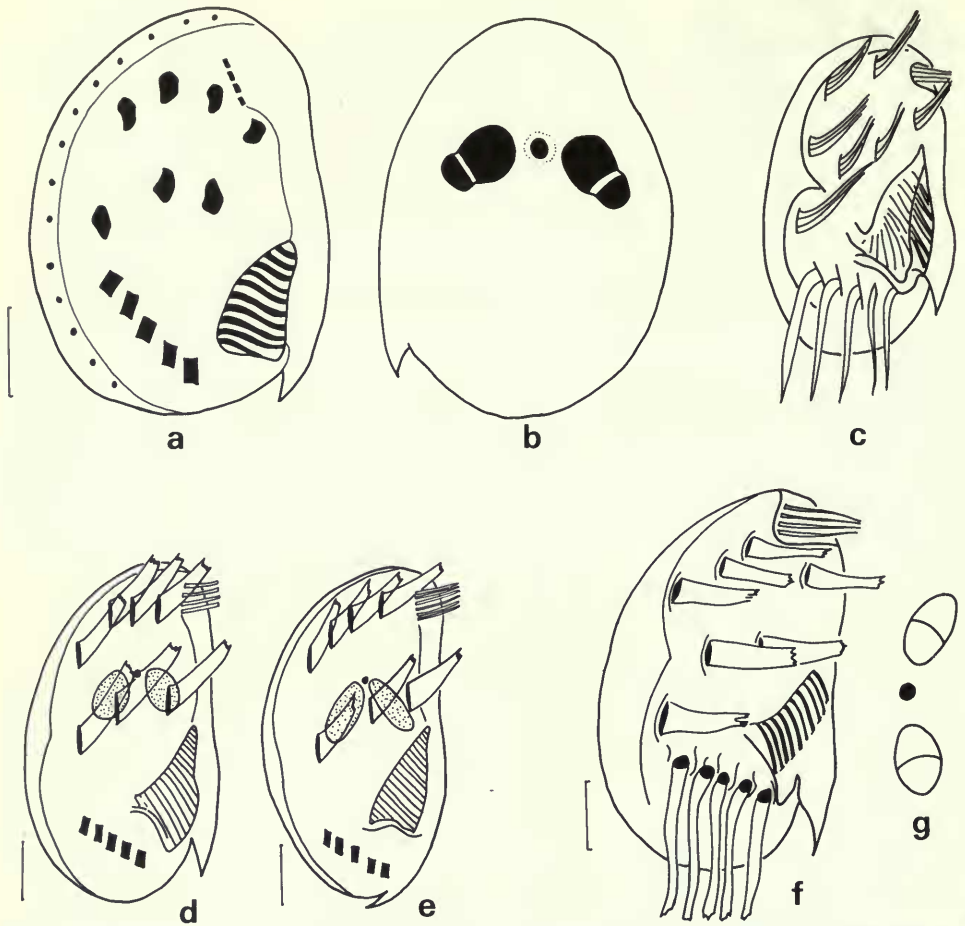

Fig. 24 *Aspidisca fusca*: (a–b) after Agamaliev, 1967; (c) after Kahl, 1932; (d) after Burkovsky, 1970; (e) after Burkovsky, 1970 (called *A. irinae*); (f–g) after Dragesco, 1965.

Aspidisca fusca Kahl, 1928

Aspidisca irinae Burkovsky, 1970

This species was first found in Oldesloe, Kiel. In the original description, Kahl (1928) did not mention the nuclei but Dragesco (1965) identified specimens from Port Etunnie and reported the presence of two macronuclei. Agamaliev (1967) was unsuccessful in silver-impregnating the dorsal argyrome of specimens from the Caspian Sea but successfully stained the ventral cirri and a lateral kinety. Burkovsky (1970) described *A. fusca* with frontoventral cirri in an uncharacteristic arrangement which the present authors would question. In the same paper Burkovsky described a new species *A. irinae* which is practically identical to *A. fusca* and is here regarded as a synonym.

DIAGNOSIS. *Aspidisca fusca* (Fig. 24) is a small to medium size (40–60 μm) species. The body is oval, slightly convex on the right, and the dorsal surface is arched and smooth. There are seven frontoventral cirri in 'polystyla-arrangement' and five transverse cirri. The peristome is small

with 10–12 membranelles in the posterior AZM and there are four to six anterior cilia. Two centrally located oval macronuclei are arranged in an inverted 'V' shape with a spherical micronucleus situated between. The prominently developed peristomial spur distinguishes this species from *A. major*.

Aspidisca sedigita Quennerstedt, 1867

Aspidisca hexeris Quennerstedt, 1869
Aspidisca crenata Fabre-Domerque, 1869
Aspidisca angulata Bock, 1952
Aspidisca pertinens Bock, 1955
Aspidisca fjeldi Dragesco, 1960
Aspidisca tridentata Dragesco, 1963
Aspidisca caspica Agamaliev, 1967
Aspidisca fuscoides Agamaliev, 1975

Aspidisca sedigita is in almost every respect like *Aspidisca leptaspis* described by Fresenius two years earlier, but the absence of a VI/2 cirrus distinguishes *A. sedigita* from the earlier species. The four species *A. hexeris*, *A. crenata*, *A. pertinens* and *A. fjeldi* are all of similar size, shape and ciliature to *A. sedigita* but have been designated as separate species since they have only one or no projection on the left border other than the peristomial spur. As we do not consider lateral projections to be stable taxonomic features the above listed species are regarded as synonyms of *A. sedigita*. The two species *A. tridentata* and *A. caspica* both have three dentations on the left border are undoubtedly identical to *A. sedigita*.

DIAGNOSIS. *Aspidisca sedigita* (Fig. 25) is a medium size (50–100 μm) species. Its shape is typical of the genus, oval and convex on the right. On the left border is a prominent peristomial spur and one or two smaller projections. The posterior border may be serrated and the dorsal surface is marked by two to four grooves. There are seven frontoventral cirri in 'polystyla-arrangement' and six to seven transverse cirri. The peristome is of average size and there are four to eight anterior cilia. The macronucleus is horseshoe-shaped and up to three micronuclei have been observed. According to the description of *A. caspica* by Agamaliev (1967, 1970), the silver-line system consists of five dorsolateral kineties carrying a variable number of cilia and the argyrome pattern is also variable.

Aspidisca orthopogon Deroux & Tuffrau, 1965

This species has been described only by Deroux & Tuffrau (1965) who gave a detailed account of the morphogenesis of the ventral ciliature.

DIAGNOSIS. *Aspidisca orthopogon* (Fig. 26) is one of the few larger (80–110 μm) species of the genus. Its outline is smooth and the body a perfect oval without being convex on the right, as is typical of the genus. Other than seven frontoventral cirri in 'polystyla-arrangement', it has a satellite-like V/3 cirrus (also named 'cirre surnuméraire' by Deroux & Tuffrau, 1965) and not the VI/2 cirrus found in the other species with eight frontoventral cirri. Its peristome with 40–50 membranelles in the posterior AZM is uniquely extensive and there are four anterior cilia. The macronucleus is a classic horseshoe and the micronucleus is by its anterior left. The silver-line system consists of four symmetrically aligned dorsal kineties each carrying more than 30 cilia, and simple transverse links forming a 'draught-board' pattern.

Aspidisca leptaspis Fresenius, 1865

Aspidisca psammobiotica Burkovsky, 1970
[*Aspidisca lyncaster* Stein; Kahl, 1932 Misidentification]
[*Aspidisca lyncaster* Stein; Dragesco, 1960 Misidentification]
[*Aspidisca lyncaster* Stein; Tuffrau, 1964 Misidentification]

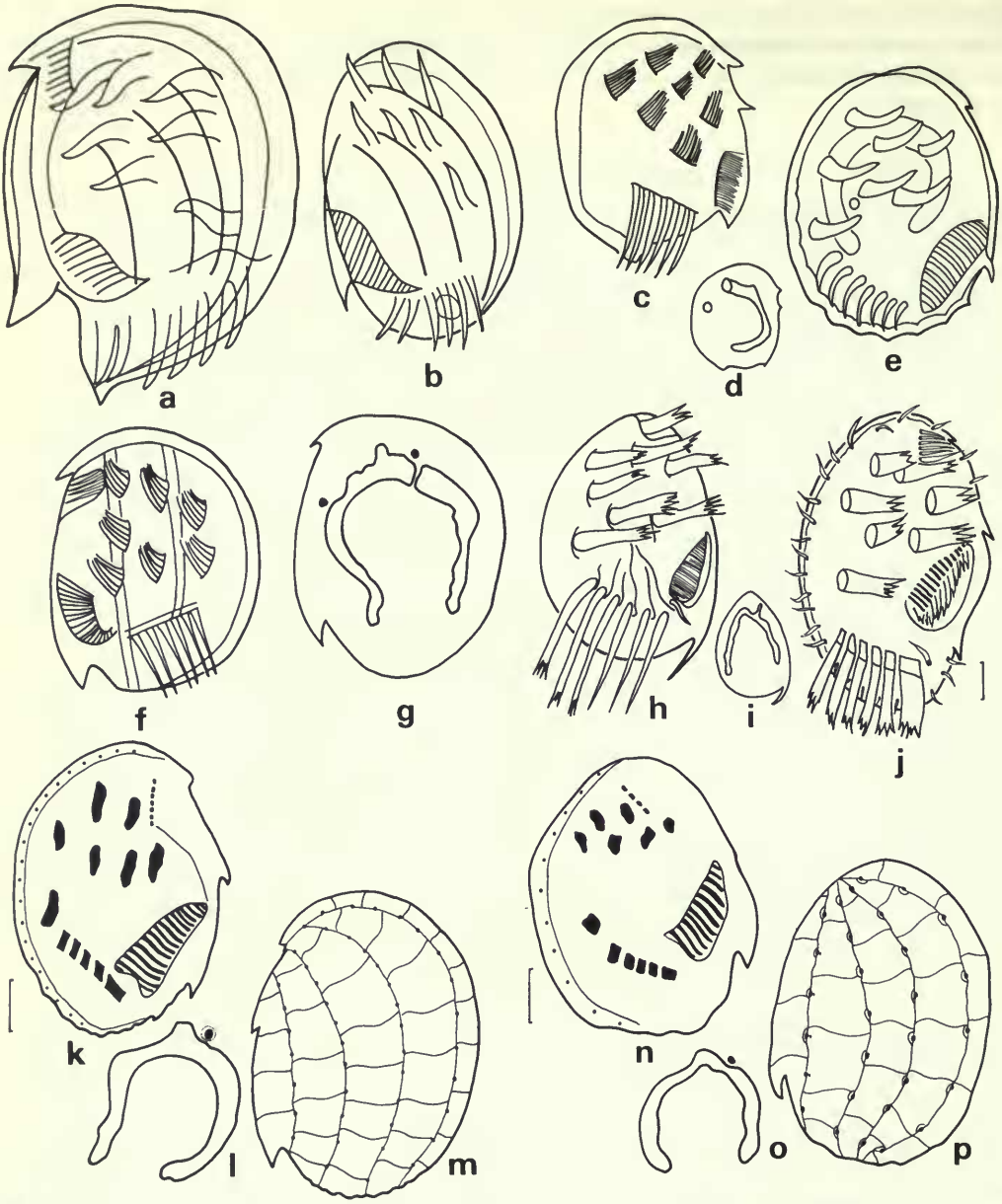

Fig. 25 *Aspidisca sedigita*: (a) after Quennerstedt, 1867; (b) after Quennerstedt, 1869 (called *A. hexeris*); (c–d) after Bock, 1952 (called *A. angulata*); (e) after Fabre-Domerque, 1885 (called *A. crenata*); (f–g) after Bock, 1955 (called *A. pertinens*); (h–i) after Dragesco, 1960 (called *A. fjeldi*); (j) after Dragesco, 1963 (called *A. tridentata*); (k–m) after Agamaliev, 1967 (called *A. caspica*); (n–p) after Agamaliev, 1975 (called *A. fuscoides*).

[*Aspidisca sedigita* Quennerstedt; Kahl, 1932 Misidentification]
[*Aspidisca sedigita* Quennerstedt; Dragesco, 1960 Misidentification]

Fresenius (1865) found a large and a small (30–35 μm) *Aspidisca* in a seawater acquarium. He stated that the former was similar to *A. lyncaster* and described the latter as *A. leptaspis*. Since Kahl (1932) found large specimens of the latter species, it is likely that Fresenius described two different size groups of the same species. There are eight frontoventral cirri illustrated in Fresenius's

diagram which we consider are a major diagnostic feature. Two species, *A. lyncaster* (Muller) Stein and *A. sedigita* Quennerstedt, have been described with similar ciliature but only seven frontoventral cirri. Tuffrau (1964) described the silver-line system of what he identified as *A. lyncaster* but with eight frontoventral cirri and it is similar to that of *A. leptaspis* illustrated by Agamaliev (1974).

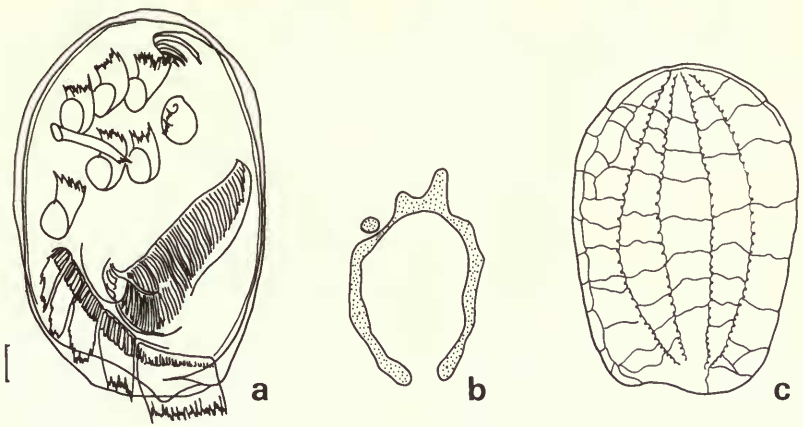

Fig. 26 *Aspidisca orthopogon*: (a) ventral ciliature; (b) nuclei; (c) dorsal silver-line system (after Deroux & Tuffrau, 1965).

DIAGNOSIS. *Aspidisca leptaspis* (Fig. 27) is a small to medium size (30–90 μm) species. It is characterised by the presence of a prominent peristomial spur and a satellite-like VI/2 cirrus which together with seven other frontoventral cirri in 'polystyla-arrangement' make a total of eight. One or two small dentations may be found at the anterior left and serrations on the posterior border. There are five or six transverse cirri and three or four dorsal ribs. The peristome is fairly extensive accommodating about 15 membranelles in the posterior AZM and the anterior ciliary organelle consists of six to eight cilia. The macronucleus is a perfect horseshoe and two micronuclei have been seen. The silver-line system is of five dorsolateral kineties, the dorsal kinety on the extreme right hand runs along the border and joins the two central kineties anteriorly. Simple transverse links join the kineties. The longest dorsal kinety on the right carries about 20 cilia (see Agamaliev, 1974).

Aspidisca pulcherrima Kahl, 1932

Aspidisca pulcherrima var. *baltica* Kahl, 1932
Aspidisca baltica Borror, 1965

This species was originally described from the North Sea by Kahl (1932). Tuffrau (1964) identified this species from Roscoff and described its silver-line system but did not mention any crenated dorsal ribs which is a distinctive feature described by Kahl (1932). Kahl (1932) also described a variety, *A. pulcherrima* var. *baltica*, on the seaweed *Ulva* in the Baltic Sea which he considered had a less serrated posterior border and the dorsal ribs bore 'humps' rather than 'teeth'. Borror (1965) redescribed this variety and raised it to species level for similar reasons, noting that it also had a distinct configuration of the 'right lip of the buccal cavity' and ventral argyromes. Since we do not consider these features as diagnostic characters this variety is treated as a synonym. Borror (1965) also illustrated the silver-line system which agrees with that given by Tuffrau (1964).

DIAGNOSIS. *Aspidisca pulcherrima* (Fig. 28) is a medium size (70–90 μm) species characterised by four crenated dorsal ribs and a rugged body outline. Apart from a prominent peristomial spur, there may be two smaller projections on the anterior left border. Along the posterior border are

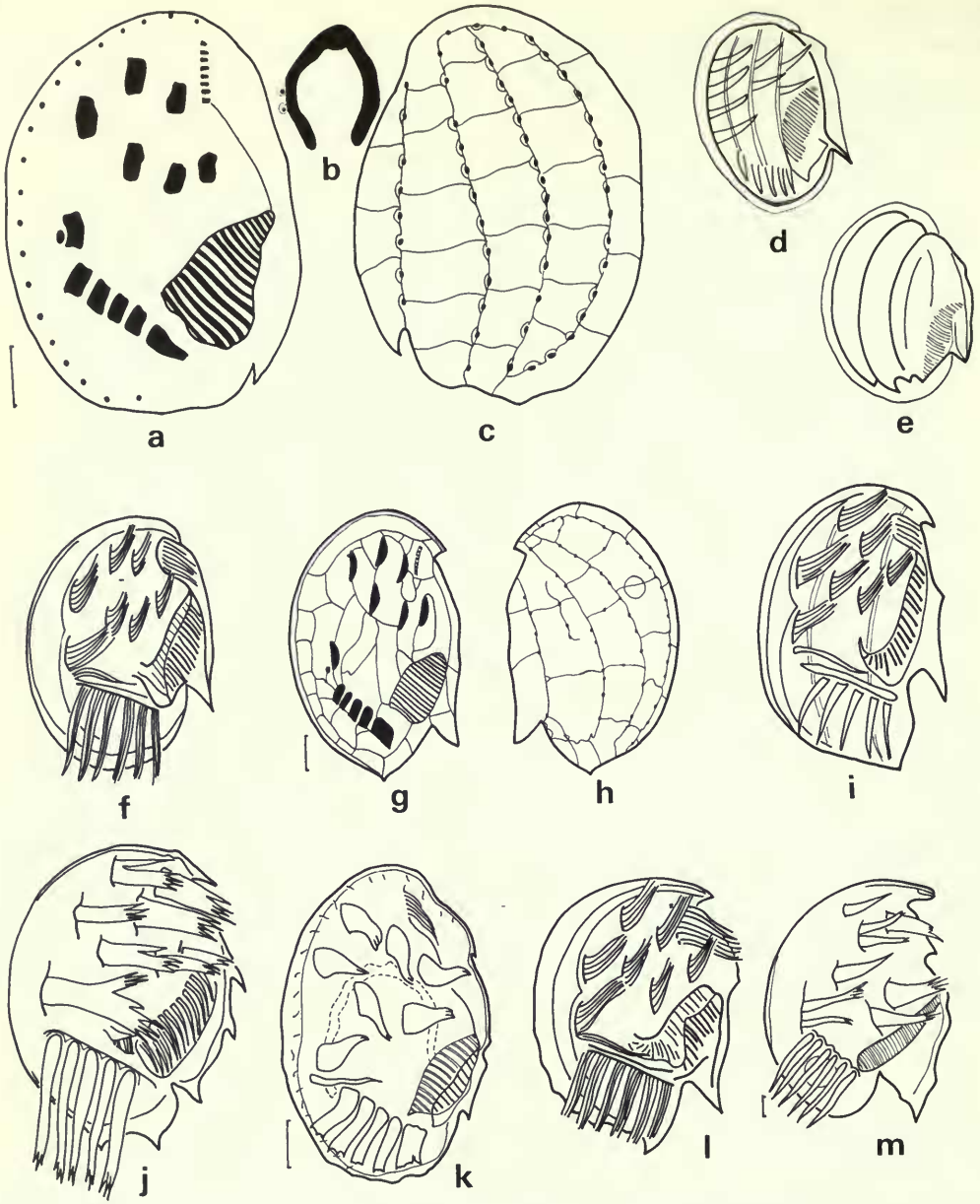

Fig. 27 *Aspidisca leptaspis:* (a–c) after Agamaliev, 1974; (d–e) after Fresenius, 1865; (f) after Kahl, 1932; (g–h) after Burkovsky, 1970 (called *A. psammobiotica*); (i) after Kahl, 1932 (called *A. lyncaster*); (j) after Dragesco, 1960 (called *A. lyncaster*); (k) after Tuffrau, 1964 (called *A. lyncaster*); (l) after Kahl, 1932 (called *A. sedigita*); (m) after Dragesco, 1960 (called *A. sedigita*).

three to four pronounced dentations and the posterior half of the right border is also slightly serrated. There are six or seven transverse cirri and seven frontoventral cirri in 'polystyla-arrangement' plus a satellite-like VI/2 cirrus making eight in all. The macronucleus is C-shaped with one or two micronuclei at its immediate left. There are 15–20 membranelles in the posterior AZM and four to eight anterior cilia. The silver-line system consists of four kinety meridians and simple irregular transverse links.

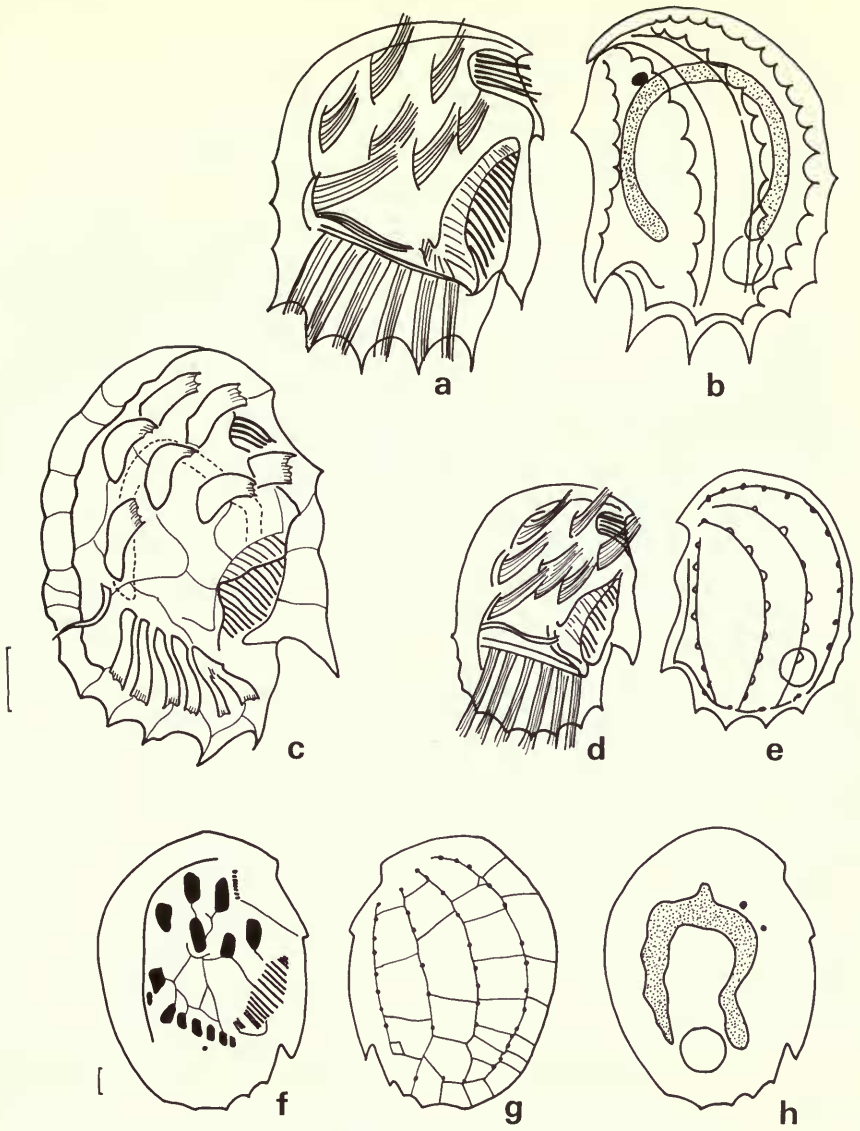

Fig. 28 *Aspidisca pulcherrima*: (a–b) after Kahl, 1932; (c) after Tuffrau, 1964; (d–e) after Kahl, 1932 (called *A. pulcherrima* var *baltica*); (f–h) after Borror, 1965 (called *A. baltica*).

Section C

Key to species with more than eight frontoventral cirri

1 a 11–15 frontoventral cirri and a keel-like dorsal spine . . . . . ***A. mutans***
b 9 frontoventral cirri and 2 macronuclei . . . . . ***A. binucleata***

Aspidisca mutans Kahl, 1932

The large number of cirri on the ventral surface and the keel-like dorsal spine of *A. mutans* are unique to the genus. The description of this species from Kiel is the only source of information.

DIAGNOSIS. *Aspidisca mutans* (Fig. 29) is a large (90–150 μm) species. The oval body is convex on the right and the outline is smooth. It has 11–15 frontoventral cirri aligned in two rows each

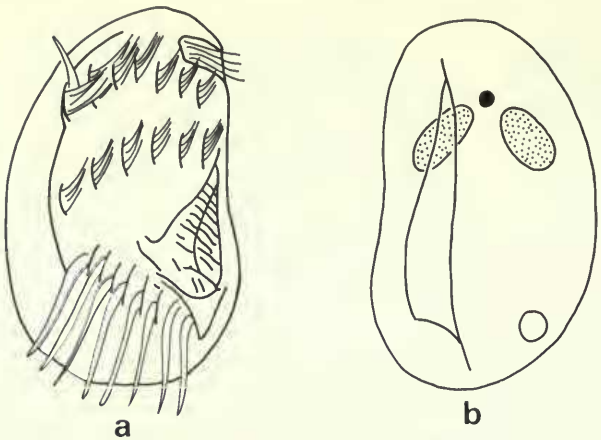

Fig. 29 *Aspidisca mutans*: (a) ventral surface; (b) dorsal surface; (after Kahl, 1932).

with five to seven, and six to eight cirri. A satellite-like cirrus by the anterior right border and seven to eight transverse cirri make a total of up to 24 cirri on the ventral surface. The two oval macronuclei are small and are located anteriorly. The micronucleus is at the apex of the inverted 'V' formed by the macronuclei. There is a keel-like spine dorsally which may 'vary in its acuteness but is seldom absent'.

Aspidisca binucleata Kahl, 1932

The description of this species by Kahl is brief. *A. binucleata* differs from *A. major* only in having nine frontoventral cirri instead of seven.

DIAGNOSIS. *Aspidisca binucleata* (Fig. 30) is a medium size (70–90 μm) species and the outline of the oval body is smooth. There are nine frontoventral cirri, six transverse cirri, 15–20 membranelles in the posterior AZM and four anterior cilia. The two small round macronuclei and a micronucleus on their right are found in the anterior half of the body.

Doubtful species

Aspidisca caudata Vacelet, 1961

This species (Fig. 31) found at the marine station of Endorome-Marseille is 50–65 μm long. There are two dentations on the left border, seven frontoventral cirri in 'polystyla-arrangement', five

Fig. 30 *Aspidisca binucleata* after Kahl, 1932.

transverse cirri and a horseshoe macronulceus which are diagnostic features of *A. sedigita*. Vacelet (1961*a*) noted a tail-like structure which did not function as a flagellum nor as a cilium but trailed behind, and sometimes the animal seemed to be attached to the substrate by this 'tail'. Vacelet stated, however, that the rare individuals were briefly seen once on the surface of a sediment sample, therefore the present authors are reluctant to regard this as a distinct species until further confirmation and information on this tail-like structure become available.

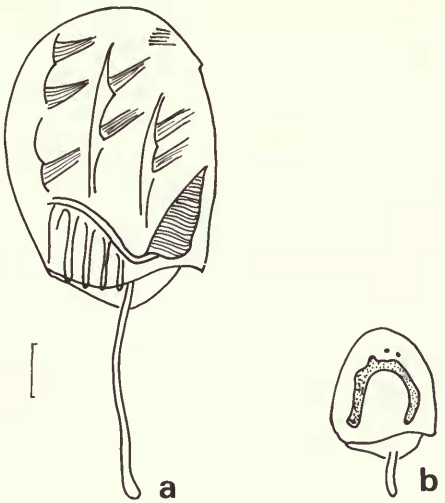

Fig. 31 *Aspidisca caudata*: (a) ventral surface; (b) nuclei (after Vacelet, 1961*a*).

Nomena nuda

Aspidisca bipartita Gourret & Roeser, 1886
Aspidisca denticulata Ehrenberg, 1838
Aspidisca pulvinata Fromentel, 1874
Aspidisca radiata Fromentel, 1874
Aspidisca robusta Kahl, 1932

Appendix 1

Plough's key for identification of the species of *Aspidisca* (Plough, 1916)

A.	Right and left border smooth	a
B.	Left border incised to form a single backwardly directed spur in the posterior third	***A. hexeris***
C.	Left border with two spurs, one in the anterior and one in the posterior third . . .	c
D.	Left border with three spurs	***A. sedigita***
	a. Dorsal surface with recurved thorn-like appendage	***A. turrita****
	Dorsal surface without thorn	a'
	c. Dorsal surface and posterior border serrated	***A. leptaspis***
	Dorsal surface smooth	***A. lyncaster***
	a' Ventral plate projecting beyond left border of carapace	***A. costata****
	Ventral plate not projecting	a''
	a'' Peristome reaching anterior border, anal cirri five	***A. lynceus***
	Peristomial cilia not reaching anterior border, anal cirri more than five .	***A. polystyla***

* Indicates the only forms so far reported in freshwater.

Appendix 2

Kahl's key for the identification of species of *Aspidisca* (translated from Kahl, 1932)

1(14)	Freshwater, always with five transverse cirri	2
2 (5)	Transverse cirri in an oblique row at or near the posterior border	3
3 (4)	Transverse cirri at posterior border, only five ventral cirri.	***Aspidiscopsis bengalensis***
4 (3)	Transverse cirri near posterior border, dorsal with four delicate streaks	***A. marsupialis***
5 (2)	Transverse cirri far from the posterior border, the three right transverse cirri are on a ledge	6
6 (9)	The two left transverse cirri are divided at their base by a prominent spike.	7
7 (8)	Dorsal entirely smooth, without ribs and thorns	***A. lynceus***
8 (7)	Dorsal with a thorn arched towards the posterior, the remain surface flat or with delicated longitudinal ribs	***A. turrita***
9 (6)	The two left transverse cirri are not divided by a spike	10
10(11)	Ventral plate forms a tooth on the left, dorsally there are four ribs, of these, the second from the left almost always bears a thorn.	***A. herbicola***
11(10)	Ventral plate without tooth on the left, no thorn dorsally but there are three to six ribs	12
12(13)	Small, almost always strongly arched form with six dorsal ribs	***A. costata***
13(12)	Somewhat larger species with three tall dorsal ribs	***A. sulcata***
14 (1)	Marine species, almost always with six transverse cirri	15
15(34)	No teeth on the left of peristome (one species with five transverse cirri exhibit a tooth adjacent to the flattened side)	16
16(19)	Five transverse cirri	17
17(18)	Next to the peristome on the left, one finds turning of the body, nevertheless, the tooth lies visible	***A. fusca***
18(17)	No lateral tooth next to the peristome	***A. major*** ***A. steini* var. *major***
19(16)	More than five transverse cirri	20
20(33)	Six transverse cirri	21
21(22)	Moderately large flat form with two rounded nuclei (also uncoloured towards the rim) and nine frontoventral cirri	***A. binucleata***
22(21)	Small differently shaped species, always with seven ventral cirri.	23
23(24)	Dorsally are four ribs varying in height, the second from the left of these is almost always long, it bears a very variable thorn	***A. aculeata***
24(23)	Dorsal without thorn, entirely flat or with ribs	25
25(26)	Dorsal flat	***A. steini***
26(25)	Dorsal with ribs	27
27(28)	Dorsal surface strongly arched, with eight clearly marked ribs, posterior edge of the peristome has projection directed back	***A. polypoda***
28(27)	Flattened, with five to six weak ribs	29
29(30)	The peristomial deck forms a prominent triangle	***A. andreewi***

30(29) The posterior edge of the peristome forms a short blunt tooth, this projects back towards the two left transverse cirri 31

31(32) The four (or six) lower but sharply drawn ribs bear at regular intervals, small humps . . . . . ***A. tuberosa***

32(31) The four ribs have no humps, sometimes the left rib is not discernible . . . . . ***A. quadrilineata***

33(20) Seven to twelve transverse cirri 33a

33a(33b) Seven, eight or nine transverse cirri and always in same proportion with 11, 13 or 15 ventral cirri . . . . . ***A. mutans***

33b(33a) 10 to 12 transverse cirri but only seven ventral cirri . . . ***A. polystyla***

34(15) On the left of the peristome, the left border bears a broad horizontal tooth. The following species (perhaps with name *A. dentata*) form a distinct subgroup of the genus distinguished by the five to seven relatively short broad transverse cirri inserted obliquely, also the seven ventral cirri are conspicuously broad, frequently at the posterior of the ventral cirri stands a slender side-cirrus lying alongside the transverse ledge 35

35(36) Small form, from a dorsal ridge, a thorn arches towards the posterior . . . . . ***A. dentata***

36(35) Dorsal without thorn 37

37(46) The anterior border has an obvious tooth and from there the left side of the nucleus begins (cf. *A. robusta*) 38

38(43) Six transverse cirri, a side-cirrus at the posterior of the ventral cirri, a tooth-like projection at the anterior third on the left border, the right edge is very flat and transparent, in the frontal group there are six to eight membranelles 39

39(42) The posterior border has four to five teeth 40

40(41) The posterior has four or five sharply pointed teeth, dorsally are four high ribs with sharp teeth . . . . . ***A. pulcherrima***

41(40) The posterior teeth weakly developed, can also be distinct, dorsal ribs low, bear only humps . . . . . ***A. pulcherrima* var *baltica***

42(39) The posterior border shows a tooth only on its left edge and is only very weak in the remainder, dorsally are four variably clear low ribs, often only the two middle one are strongly developed . . . . . ***A. sedigita***

43(38) Five or seven transverse cirri. 44

44(45) Five transverse cirri otherwise like the preceeding species . . ***A. lyncaster***

45(44) Seven transverse cirri, the posterior edge either without distinct teeth or weekly notched . . . . . ***A. crenata***

46(37) The front left edge forms no distinct tooth, on the left side of the body is without distinct break or with a small indentation 47

47(50) Dorsal ridges weakly indicated 48

48(49) Large flat transparent species with three or four weakly indicated ridges, tooth on the left border exists strongly . . . . ***A. leptaspis***

49(48) Small slender form with a weak tooth on the left border . . ***A. hexeris***

50(47) Four or six strong ribs dorsally 51

51(52) Medium size form, with six to seven uniformly high and strong but round ribs . . . . . *A. robusta*

52(51) Very large form with two medial wing-like and two low lateral dorsal ribs . . . . . *A. magna*

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